ILLINOIS BIOLOGICAL MONOGRAPHS

Volume XVI

PUBLISHED BY THE UNIVERSITY OF ILLINOIS

URBANA, ILLINOIS

TABLE OF CONTENTS

Nos. 1-2. The Turtles of Illinois. By ALVIN R. CAHN.

No. 3. The Phylogeny of the Hemiptera, Based on a Study of the Head Capsule. By CHARLES STOCKMAN SPOONER.

No. 4. A Classification of the Larvae and Puparia of the Syrphidae of Illinois, Exclusive of Aquatic Forms. By ELIZABETH M. HEISS.

ILLINOIS BIOLOGICAL MONOGRAPHS

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THE TURTLES OF ILLINOIS

WITH 31 PLATES, 20 MAPS, AND
15 TEXT-FIGURES

BY
ALVIN R. CAHN

CONTRIBUTION FROM THE ZOOLOGICAL LABORATORY OF THE
UNIVERSITY OF ILLINOIS
No. 492

PREFACE

For a number of years the writer has had in mind the production of a monograph dealing with the turtles of Illinois, if for no other reason than the fact that they have, as a group, been much neglected throughout the middle west. In most herpetological literature of the region much space has been given to snakes, salamanders, and frogs, but turtles have received at best a mere mention, being passed off with the enumeration of a species or two in a given locality. This is perhaps due to the difficulty of capturing specimens, coupled with the uncertainty of identifying most species as they sit sunning themselves in security on a log in the middle of a pond, and the very awkward problem of keeping such bulky creatures once they are captured. I suspect, however, that it is also in part due to the fact that there is really very little literature available to the average student or field collector which will enable him to identify with ease and certainty a species once he catches it. Keys there are, but many are located in old publications not everywhere available; many are so highly technical as to require an advanced knowledge of comparative anatomy for their comprehension and use; others are too superficial and general to be of really practical value. It has been the writer's plan, therefore, to present a paper dealing with the various species of turtles found within the boundaries of Illinois, this paper to include keys to the families, genera, and species—intelligible to readers who are not professional herpetologists—together with a full discussion of the life history of each species so far as it is known. Such a discussion must also contain a detailed description of the adult and young, eggs, habits, economic importance, food habits, sex differentiation, and parasites, in order to approach completeness. One real drawback, as the writer sees it, to the ready identification of turtles, is the lack of adequate photographs that will in themselves be an aid (and not a handicap) in the determination of the identity of the species. To that end he has bent every effort to illustrate the present paper with the best photographs he could obtain. All the illustrations are original and have been made especially for this monograph. The photographs are either from living specimens or from freshly preserved material, in the latter case photographed within an hour after killing so as to insure full color values.

The writer has drawn freely upon available literature, as will be seen on consulting the bibliography. This bibliography has been arranged under several headings so as to make it of greater use to both the amateur and the professional student.

The Illinois State Natural History Survey, under the direction of Dr. Theodore H. Frison, has placed at the writer's disposal its collections of Illinois turtles. Unfortunately, the original collection made by Professor H. Garman in 1888 for the State Laboratory of Natural History has disappeared and hence has not been available for study. This has proved to be a serious handicap, for the writer has been unable to obtain specimens of several species listed by Garman from Illinois. To Dr. David H. Thompson and Mr. Francis D. Hunt, of the Natural History Survey, the writer expresses his appreciation for their assistance in procuring specimens for examination from various parts of Illinois, and to the commercial fishermen who have sent in many sacks and barrels full of live turtles for study, the writer owes in large measure the information concerning the geographical distribution within the state. During the summer of 1931, Mr. Joe D. Combs, of the Zoology Department of the University of Illinois, spent two months under the writer's direction, on the Illinois River at Meredosia, collecting information on life histories and obtaining many interesting facts.

To the many friends all over the country who submitted material for comparison and for study, and to the American Museum, the Field Museum, and the United States National Museum, the writer expresses his deep appreciation for all courtesies rendered.

CONTENTS

Illinois Topography and Hydrography 9

Historical Review 16

Key to the Families of Illinois Turtles 20
- Key to the Family Chelydridae 20
- Key to the Family Kinosternidae 20
- Key to the Family Testudinidae 21
- Key to the Family Trionychidae 22

Family Chelydridae 23
- Genus Macrochelys 23
  - Macrochelys temminckii 24
- Genus Chelydra 34
  - Chelydra serpentina 34

Family Kinosternidae 46
- Genus Sternotherus 46
  - Sternotherus odoratus 47
- Genus Kinosternon 56
  - Kinosternon flavescens 56
  - Kinosternon subrubrum subrubrum 62

Family Testudinidae 67
- Genus Clemmys 68
  - Clemmys guttata 68
- Genus Emys 75
  - Emys blandingii 75
- Genus Terrapene 83
  - Terrapene carolina carolina 84
  - Terrapene ornata 96
- Genus Graptemys 103
  - Graptemys geographica 105
  - Graptemys pseudogeographica pseudogeographica 113
- Genus Chrysemys 122
  - The Chrysemys Problem 123
  - Chrysemys picta marginata 129
  - Chrysemys picta bellii 138
  - Chrysemys picta dorsalis 145
- Genus Pseudemys 152
  - Pseudemys concinna 152
  - The Pseudemys elegans-troostii Problem 159
  - Pseudemys troostii 160
    - Melanistic Males 169

Family Trionychidae 175
- Genus Amyda 175
  - Amyda mutica 176
  - Amyda spinifera 184

CONTENTS (Concluded)

Hypothetical List 194
Sternotherus carinatus 195
Chrysemys picta. 199
Amyda ferox 199
Chrysemys treleasei 200
Pseudemys hieroglyphica 201
Clemmys insculpta 203

Bibliography 208
Illinois References 208
General References 209
References for Adjacent States 212
References for Synonymy 214

Glossary. 217

ILLINOIS TOPOGRAPHY AND HYDROGRAPHY

The state of Illinois occupies a unique position geographically in the United States, for within its borders many of the major faunal and floral features of the east and west, the north and south, join and to some extent overlap or intergrade. Here representative species of the eastern forests and the western prairies, of the northern and southern forests, come together, and meet with the species of the sand dune region of Lake Michigan. Hence, as one might expect, the biota is varied and rich.

Illinois is essentially a prairie state, but about 42 percent of its total area, or about fifteen million acres, is classified ecologically as having been originally deciduous forest of various types. This great forest, before being destroyed by man, covered most of the southern third of the state, as well as the northeastern section. Here roamed the white-tailed deer *(Odocoileus virginianus),* the black bear *(Euarctos americanus),* timber wolf *(Canis lycaon),* gray fox *(Urocyon cinereoargenteus),* and red fox *(Vulpes fulva).* The remaining region, approximately 58 percent of the total area, was of parkland formation: grass prairies, with clumps of trees scattered through it. With the colonization of the state and its phenomenal growth in population, the forested region was reduced, until at present it is represented by less than 3,000,000 acres. With the deforestation came the cultivation of the land, and this was subsequently accompanied by drainage. The present biota is the product of these changes. Deforestation automatically and directly eliminated the larger species of forest animals, while the indirect effects of deforestation —cultivation and drainage—have had a profound influence upon the aquatic biota. The deforested land can no longer hold its original quota of water, and hence the run-off is rapid and sudden and spasmodic, resulting in floods and in a diminution of the volume of the rivers. There is no possible way in which we can with certainty reconstruct the original faunal distribution within the state, especially in respect to such a group as the turtles, but certain it is that the original distribution of animals was quite different from that which we see to-day. And it requires no prophet to predict that the future holds an even more profound change.

Illinois is essentially a plain, gently rolling in places, in others flat. It is the lowest (average elevation 600 feet) of all the north-central states, lying in the middle of the great interior basin of the North American continent, which is bounded on the east by the Appalachian and on the west by the Rocky Mountains. In general, the elevation decreases from north to south and from east to west, but this is in no sense a regu-

lar decline. The two essential features which interrupt the plain surface of the state are (1) the moraine features of the drift area, and (2) the rock ridges.

The drift areas of Illinois are important in relation to the drainage basins of the state. The southern limit of the glacial drift within Illinois lies at the foot of the Ozark uplift in the southern part of the state; from here is passes eastward into Indiana, and north and west to East St. Louis and Quincy. Thus the major portion of the state is covered with drift (the Illinoian drift of the geologist), with a small area of driftless, non-glaciated country at the extreme southern tip and following up the Mississippi River valley to Quincy and up the Ohio River valley into Indiana, and a second, isolated area in the northwestern corner of the state. The northeastern quarter of the state has for its outstanding topographic features a series of terminal moraines which mark the irregular southern limits of the Michigan lobe of the Labrador glacier, this region being covered with early Wisconsin drift. The narrow band along the shore of Lake Michigan is the Valparaiso moraine, late Wisconsin in origin. These morainic ridges were formed by the retreat of the ice sheet from the Shelbyville moraine and are separated by drift-covered basins which undoubtedly represent old lake beds. The slope of these ridges is gentle on the side that was away from the glacier (west and south) and much more abrupt on the side toward the ice (toward Lake Michigan). Thus the streams are found to flow through these basins, receiving as their tributaries smaller streams flowing down the gentle slopes of the moraines. Hence the drainage of this Wisconsin drift area flows mainly to the south and west. Over the Illinoian drift area the drainage is toward the Mississippi River, in a southwesterly direction. At the southwestern tip of Lake Michigan lies the Valparaiso moraine, the terminus of the late Wisconsin ice sheet; between this and Lake Michigan flow the Des Plaines, Calumet, and Chicago rivers, the last two flowing into Lake Michigan (originally at least), the former finding an outlet through the moraine at an ancient outlet of Lake Michigan known as the "old Chicago outlet."

There are but few places where the underlying rock rises above the superimposed drift, these being in the northwest corner, where the Niagara limestone breaks through to the surface and where there never was any glacial drift; the southern end of the state, where the Ozark uplift crosses the state; and places along the Mississippi River where the lower carboniferous limestones rise as the bluffs along the eastern shore of that river. The rivers are consequently flowing largely through areas of glacial drift, connecting very few lakes, and showing but little drop

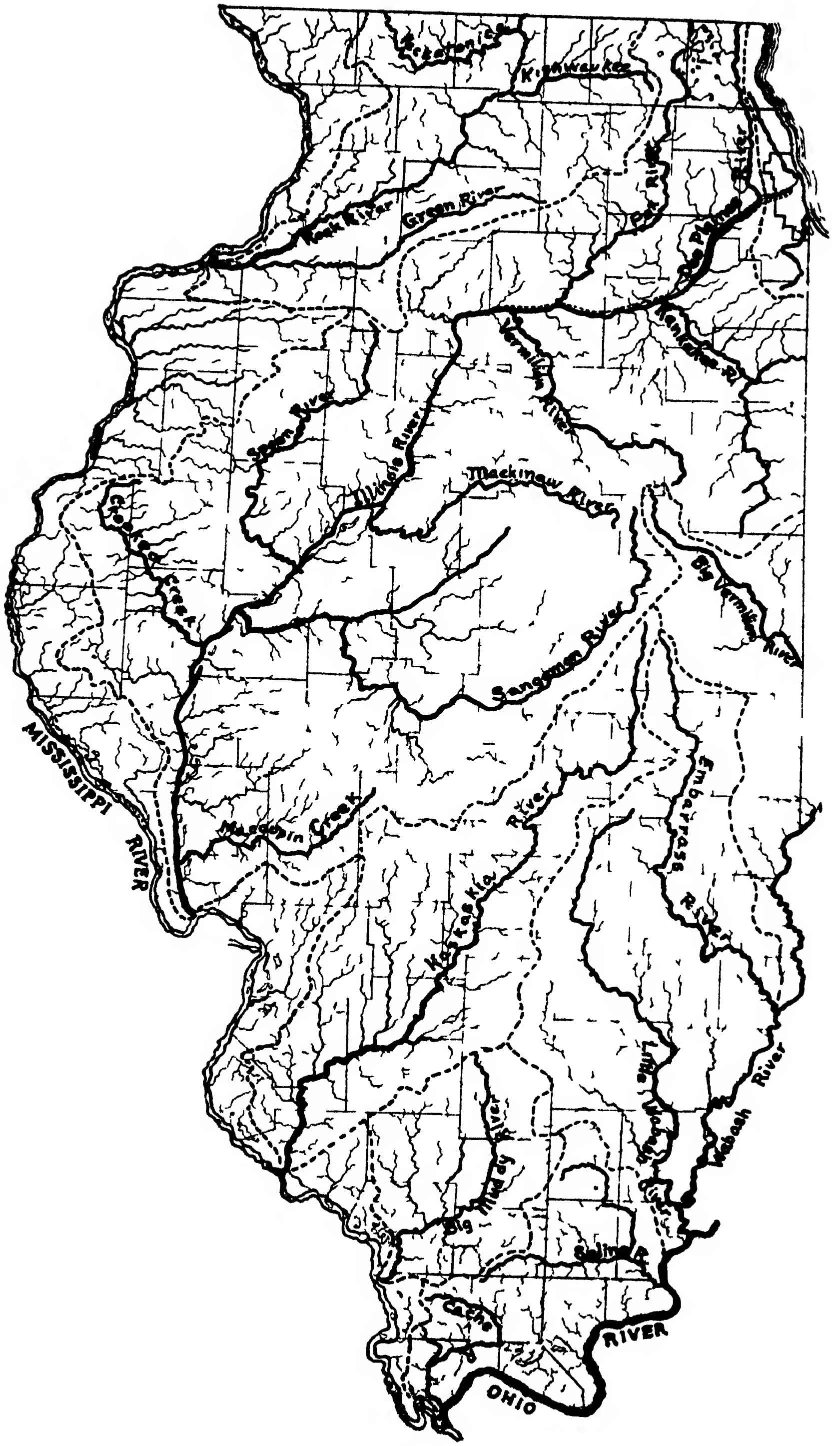
per mile and normally but a sluggish current. The average rainfall of 38.2 inches for the state affords under ordinary conditions a sufficient supply of water to the rivers. The unusual drought of 1930 left the lesser streams and smaller lakes almost destitute of water, and the larger rivers and lakes at a record low mark.

That Illinois is well supplied with streams of all sizes is recognized by a glance at the accompanying map of the river systems of the state, and one cannot help being impressed by the dendritic pattern of these streams. While there are innumerable tiny creeks throughout Illinois, the drainage of the state falls into the basins of five main rivers and Lake Michigan. All five of the rivers empty either directly or indirectly into the Mississippi River; hence all of the state, excepting only the narrow belt between the Valparaiso moraine and Lake Michigan, lies in the drainage area of the Mississippi. Since these river systems are in many cases essential to the understanding of the distribution of certain species of turtles, they are listed here, together with their approximate drainage areas (data from Leverett).

TABLE 1.—THE RIVER SYSTEMS OF ILLINOIS, WITH THEIR APPROXIMATE DRAINAGE AREAS

River system	Square miles
Mississippi River Drainage	
1. Rock River	5,310*
Green River	1,000
Pecatonica River	780*
Kishwaukee River	1,644
2. Illinois River	24,940*
Des Plaines River	1,750
Kankakee River	2,160*
Fox River	1,560*
Vermilion River	1,320
Mackinaw River	1,200
Spoon River	1,820
Sangamon River	5,590
Salt Creek	1,940
Crooked Creek	1,350
Macoupin Creek	1,000
3. Kaskaskia River	6,000
4. Big Muddy River	2,400
5. Ohio River:	
Wabash River	8,890*
Big Vermilion River	1,400
Embarrass River	2,400
Little Wabash River	3,190
Saline River	2,000
Cache River	623

*Exclusive of the drainage area outside the boundaries of Illinois.



TEXT-FIGURE 1.—THE RIVERS OF ILLINOIS

Rock River.—The Rock River rises in Dodge County, Wisconsin, and drains ten large clear-water lakes in that state. It enters Illinois in Winnebago County, flowing with considerable current although its maximum gradient is only two feet per mile. Its banks are low in many places, at least on one side, for the river wanders across its valley, which has bluffs of a moderate height.

Green River.—This river flows for a considerable distance through a channel cut in sand and gravel from the Wisconsin glacier. It is only about 93 miles in length. In its course it meanders through two large swamp areas, where it almost loses its identity as a stream and where it has practically no current, while at its headwaters it flows along with a drop of some 25 feet to the mile. Its banks are low and without bluffs.

Pecatonica River.—This river enters Illinois in Stephenson County, coming from its source in Wisconsin, its entire course in the state lying in the Illinoian drift. It flows through rolling country, some of which is timber land and some prairie, with a drop of only about 6 inches to the mile, its banks largely of rich earth and low.

Kishwaukee River.—This stream is formed by the union of two branches, each with a drop of about 3 feet per mile. Its water is quite clear as it flows through a rolling country, its banks timbered in some places, and in others of the prairie type.

Illinois River.—This is the largest river system in the state, and the river itself is the largest stream. It has a depth that varies to an extreme of approximately thirty feet. In many places it has cut its way through rock and presents beautiful high bluffs in consequence, indicating that in former years it probably had a considerably greater volume of water than it has now. Most of the course of the Illinois was down an ancient river outlet of Lake Michigan, from which, however, it is now cut off, the water of that lake having in late Pleistocene time discharged into the Mississippi instead of into the St. Lawrence. It is bordered by a large flood plain, overflowing it in periods of high water, and by a second flood plain now above the reach of even the highest water, representing the flood plain of the river at the time it received the Lake Michigan discharge. Within this second bottom area there are, in some places, small lakes. The river flows through many swampy areas (overflow ponds) and has a very large population of turtles because of the favorable environment. It is a slow river with an average drop over its entire length of but 3.2 inches per mile. It is rich in aquatic vegetation, which affords excellent shelter for its aquatic fauna. The upper reaches of the river were formerly polluted by the discharges of Chicago into it by way of the drainage canal, and here all normal river life was lacking.

Des Plaines River.—This stream drains a narrow valley lying between the moraines west of Lake Michigan, arising in Wisconsin. Its entire course lies within the late Wisconsin drift, and since this is characteristically a morainic region, many small lakes and marshes are found along its path. Its bed is, in consequence of the region through which it flows, largely sand and gravel. Its passage through the moraine which bounds it on the west is considered to be the old outlet of Lake Michigan during late Pleistocene time.

Kankakee River.—This river has its origin in Indiana, where it flows through what is considered as a glacial lake bed, that of Lake Kankakee. Its valley is therefore quite level, the drop in the 240 miles lying in Indiana averaging less than 5 inches per mile. In Illinois it encounters its limestone base and drops more precipitately at certain points due to this factor. Its bed is largely gravel and rock.

Fox River.—This river rises in Waukesha County, Wisconsin, where it flows through the Wisconsin drift area, connecting a large series of beautiful clear-water lakes. In Illinois it continues its progress through the Wisconsin drift, to enter the Illinois River at Ottawa. Much of its drainage basin lies in morainic areas from which, however, many of the lakes have disappeared because of drainage and cultivation. It is stated that the volume of the river has fallen off at least 50 per cent due to this drainage and cultivation. The channel is therefore narrow and in some places has precipitous banks. It drops from 3 to 5 feet per mile.

Vermilion River.—This is the Vermilion River that discharges into the Illinois, not into the Wabash. It rises in the moraines of Ford and Livingston counties. It has cut for itself a deep channel through parts of its course, with precipitous bluffs and cliffs overhanging the water. It drains no lakes or marshes and hence suffers much loss of water during dry seasons.

Mackinaw River.—This stream rises in McLean County and flows southwest to enter the Illinois below Pekin. Since it starts high in the Bloomington moraine, we find that it drops 40 feet during its first mile, but then slows down to 3 feet per mile over most of its upper reaches. It flows through a very narrow channel, and since it has no marshes to take up its water, it is subject to great variation in times of either heavy rain or drought. It is considered to be the most variable stream in the state.

Spoon River.—This river rises in Bureau County, and for a large part of its course it parallels the Illinois River. It is a river with considerable current as it flows through a relatively narrow valley. In fact, its current is so much greater than that of the Illinois into which it empties at Havana, that it has built up a considerable delta in the latter river. It, too, is subject to great variations in its water content.

Sangamon River.—This stream is reported to have the largest watershed of any of the tributaries of the Illinois River. The first part of its course traverses the early Wisconsin drift, which it leaves near Decatur. Beyond this point it is considerably wider and shallower. It is subject to overflow in rainy seasons, the twelve-foot embankments not acting as a barrier at such times. Its main tributary is Salt Creek, which rises from two heads, the North and South Forks; both have their origin in the Bloomington moraine. The Sangamon has considerable current, as the gradient increases to 10 feet per mile at its mouth.

Crooked Creek.—This is the last tributary of any size of the Illinois on the western side. It flows entirely through Illinoian drift and has a channel which in places is bounded by high bluffs with limestone outcrops at intervals all along its course.

Macoupin Creek.—This flows through a broad valley of Illinoian drift, almost level, with areas of heavy timber along its banks. These banks are largely of black soil, sometimes quite high, sometimes scarcely above the level of the river.

Kaskaskia River.—This is one of the three rivers rising in the moraines of Champaign County (the other two being the Embarrass and the Sangamon). It rises in the area of the late Wisconsin drift, passing through the moraine near Shelbyville. The banks along its upper course are of mud but they become sandy downstream. It is a slow stream, its greatest drop being 3 feet to the mile, but through most of its course the drop is much less. Due to the nature of its flood plain, there is much timber along its valley. It has numerous tributaries, but these are all small.

Big Muddy River.—This is a very crooked river which shows evidence of being an old stream which has cut its channel down to drainage level, flowing through a flood plain which is broad and flat. It is slow and sluggish, dropping less than a foot a mile over most of its course. The water is very muddy for it carries much alluvial material. The last twenty miles of its course are through the Mississippi bottoms, and the backwater of the Mississippi is felt as far upstream as Murphysboro. In passing through these bottoms, the Big Muddy hugs the eastern shore, where bluffs 250 feet high bound its course on that side, the flat flood plain of the bottoms lying on the west.

Wabash River.—For nearly 200 miles the Wabash forms the boundary between Illinois and Indiana, flowing through the pre-glacial bed of a river that at one time was much larger than the present stream. It is a sluggish, muddy river with a drop of less than 8 inches to the mile. Its valley is broad and low, and its bottom lands subject to severe overflows. It is shallow for its size, and numerous rocky rapids interrupt its other-

wise tranquil course. Its water is loaded with sediment in suspension—largely silt—so that it is brown and opaque at all times.

Big Vermilion River.—The upper course of this river passes through a region deep in drift, through which it has cut a narrow course with relatively low banks. In the region of Danville, however, it has cut its way through the drift and flows between steep, high banks over a bed-rock course. Its water is fairly clear except in times of flood, and there is little vegetation in the lower reaches of its course. The upper portion, however, is shallow and weed-clogged, with water which is normally quite muddy.

Embarrass River.—The original source of this river in Champaign County is now largely corn fields, but the river starts its course as a tiny weed-choked stream in the Champaign moraine system and Wisconsin drift. Emerging into the Illinoian drift, its valley broadens greatly as its rate of drop falls to less than 1 foot to the mile. There are few tributary streams to the Embarrass as it flows through the relatively young Wisconsin drift, but in the older Illinoian area it receives many tributaries, presenting a typical dendritic system of drainage.

Little Wabash River.—This river rises in the Shelbyville moraine and flows through the Illinoian drift with an average drop of less than 2 feet to the mile. Its valley is broad, with rolling hills and considerable heavy timber growing on the rich sandy loam which is subjected to heavy overflow in flood times.

Saline River.—This stream drains southeastern Illinois which lies north of the Ozark uplift, entering the Ohio near Shawneetown, flowing through Illinoian drift. It is formed by the union of the North, South, and Middle Forks, beyond which point the Saline flows southeast along the base of the uplift. The river drops 35 feet in the 16 miles of its course. The southern banks are high, the northern relatively low, and the course is crooked and the current slight.

Cache River.—This is a small river which enters the Ohio at Mound City. It flows through the driftless area of the state, south of the Ozark uplift. Its course is through flat, alluvial material and cypress swamps, and its bottoms are subject to violent floods. It falls rapidly (150 feet) during the first 20 miles of its course, and but 50 feet in the remaining 50 miles of its length. It is believed that the valley of the Cache River was once the main discharge channel of the Ohio River.

HISTORICAL REVIEW

When one reviews the literature dealing with the Testudinata, especially in the United States, one is impressed by the lack of publications of monographic proportions; they are almost non-existent. By far the

greatest bulk of turtle literature is to be found in works of a general herpetological nature, as Harlan's *Genera of North American Reptilia* (1826), Holbrook's *North American Herpetology* (1836), Gray's many publications, Van Denburgh's *Reptiles of the Pacific Coast,* and innumerable smaller papers. Agassiz' monographic work (1857) on the turtles of the United States still remains the classic example of its kind, and has never been approached by any other publication for the wealth and originality of its contents and the value of its contributions. The other important and perhaps outstanding monographs are those of Surface (1908) on the economic status of the turtles of Pennsylvania, Babcock (1919) on the turtles of New England (which has the finest of colored plates), and Van Denburgh's *Gigantic Land Tortoises of the Galapagos Archipelago,* with which we are not concerned in the present paper. There has been no monograph of the turtles of Illinois published. There is, in fact, no monograph in existence dealing comprehensively with the turtles of the middle west or of any state in the Union west of Pennsylvania. There are numerous taxonomic and anatomical papers which the student must consult, and from the taxonomic series has grown the Stejneger and Barbour *Check List* (1933). Studies of the life histories of turtles are few and very far between, brief and usually very incomplete in the information which they offer. The greater bulk of the turtle literature consists of scattered faunal notes of the occurrence of this or that species in a given circumscribed locality.

Studies in the herpetology of Illinois have been few, and with the notable exception of Michigan, the same can truthfully be said of the surrounding states. This is exceedingly unfortunate, for we cannot but wish that the early herpetologists and general zoologists had left us a more complete record of the interesting herpetological information of their times than we find. The changes in the physical features of the state—deforestation, drainage, agriculture—must have left a profound impression on the amphibian and reptilian life of the region, and a study of these changes in relation to these animals would be most interesting and valuable, had we but the material or the data for study.

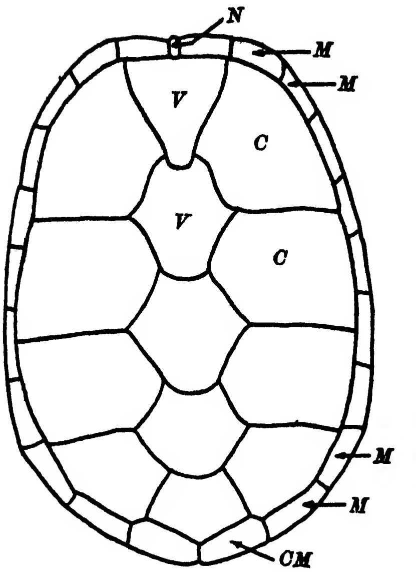
The first Illinois list of turtles is included in a very general paper dealing with the animal life of Cook County, Illinois, published by Kennicott in 1855. This list records four species: *Trionyx ferox, Cistuda blandingii, Chelonura serpentina,* and *Emys picta.* It is interesting to note that two of these species are now considered invalid for the state (*Trionyx ferox* and *Emys picta*). The second list of the herpetology of the state is that of Davis and Rice (1883), listing eight species of turtles for the entire state, three of which are no longer valid. Harrison Garman's first paper (1889), dealing with the animals of the Mississippi bottoms around Quincy, Illinois, lists nine species for that region; his

second paper (1890) adds three species to this number. The one and only comprehensive treatise on the herpetology of the state is the paper of Garman, published in 1892, in which he gives not only keys to the species, but a brief description of the forms, together with distributional notes and definite Illinois locality records. Garman's work was done for the Illinois State Laboratory of Natural History, and it is very unfortunate that all the specimens upon which this most important contribution was based have disappeared. Notes on Illinois species have appeared in many publications, and short lists of species found in various circumscribed areas, such as Blanchard's paper on southern Illinois (1924), Hankinson's on the Charleston region (1915, 1917), and Weed's notes from central Illinois (1923), all of which are helpful contributions to a more complete knowledge of the amphibians and reptiles of the state.

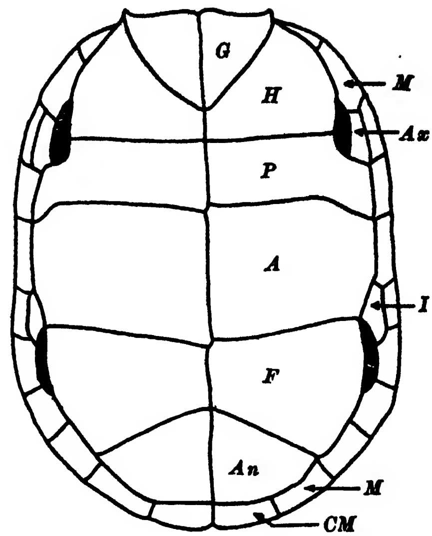
Since there is no monograph dealing with the turtles of the middle west, it is hoped that the present contribution, incomplete though it is in all its possible details, will fill for the time being a conspicuous gap. The nomenclature followed is substantially that of Stejneger and Barbour's *Check List of North American Amphibians and Reptiles* (1933), from which the writer has departed only twice: (1) in the genus Chrysemys, in which group he feels that the data presented by Bishop and Schmidt (1931) warrant the adoption of their nomenclature for this group; and (2) in the problem of the *Pseudemys troostii* vs. *Pseudemys elegans,* in which data brought to light subsequent to 1933 have made a departure from their nomenclature apparently advisable.

In order to bring before the reader the terminology as used in the present paper, with reference to the dermal and epidermal skeletal elements of the carapace and plastron, the following outline is offered:

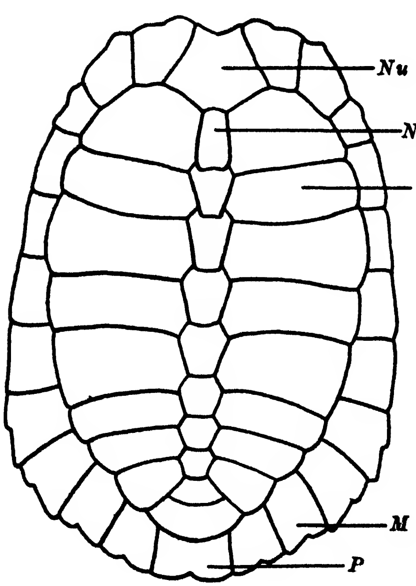
1. Epidermal skeleton, composed of scutes:
    - A. Carapace (Text-fig. 2)
        - Vertebral
        - Costal
        - Marginal
            - Nuchal
            - Caudal
    - B. Plastron (Text-fig. 3)
        - Gular
        - Humeral
        - Pectoral
        - Abdominal
        - Femoral
        - Anal
    - C. Bridge
        - Axillary
        - Inguinal
2. Dermal skeleton, composed of bony plates:
    - A. Carapace (Text-fig. 4)
        - Nuchal
        - Neural
        - Costal
        - Marginal
        - Pygal
    - B. Plastron (Text-fig. 5)
        - Entoplastron
        - Epiplastra
        - Hypoplastra
        - Hyoplastra
        - Xiphiplastra



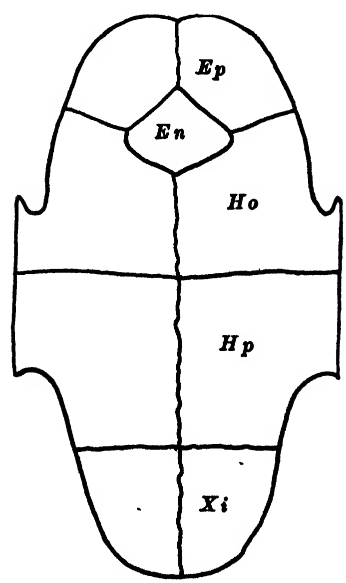
TEXT-FIGURE 2.—The scutes composing the epidermal skeleton of the carapace. *C*—costal; *CM*—caudal marginal; *M*—marginal; *N*—nuchal; *V*—vertebral.



TEXT-FIGURE 3.—The scutes composing the epidermal skeleton of the plastron. *A*—abdominal; *An*—anal; *Ax*—axillary; *CM*—caudal marginal; *F*—femoral; *G*—gular; *H*—humeral; *I*—inguinal; *M*—marginal; *P*—pectoral.



TEXT-FIGURE 4.—The bony plates composing the dermal skeleton of the carapace of *Pseudemys troostii*. *C*—costal; *M*—marginal; *Ne*—neural; *Nu*—nuchal; *P*—pygal.



TEXT-FIGURE 5.—The bony plates composing the dermal skeleton of the plastron of *Pseudemys troostii*. *En*—endoplastron; *Ep*—epiplastra; *Ho*—hyoplastra; *Hp*—hypoplastra; *Xi*—Xiphiplastra.

KEYS TO THE TURTLES OF ILLINOIS

The following keys are intended for the separation of the various species of turtles thus far reported from the state of Illinois. The characters used are, in so far as possible, external, and the keys are so developed as to be an aid to the amateur as well as to the professional herpetologist. The use of osteological or cranial characters which necessitate careful dissection or tedious cleaning up of skeletal material has been avoided wherever possible.

KEY TO THE FAMILIES OF TURTLES OF ILLINOIS

1 (6) Shell covered with horny epidermal shields........................(2)

2 (5) Pectoral shields not in contact with the marginals, but widely separated from them; plastron with 11 shields or less...............(3)

3 (4) Plastron relatively very small, cruciform, composed of 9 shields besides the bridge; carapace flaring and emarginate posteriorly; no hinges present in plastron; head very large; tail long, with dorsal crest of tubercles; 25 marginals.................CHELYDRIDAE

4 (3) Plastron larger, not cruciform, composed of 11 shields; 23 marginal shields, the carapace neither flaring nor emarginate posteriorly; symphysis of lower jaw a long, sharp point..........KINOSTERNIDAE

5 (2) Pectoral shields in contact with the marginals; plastron with 12 shields..TESTUDINIDAE

6 (1) Shell without horny shields, being covered with skin only..TRIONYCHIDAE

KEY TO THE FAMILY CHELYDRIDAE IN ILLINOIS

1 (2) No supramarginal shields; orbit directed upward and outward; head covered with skin; tail with two rows of large scales on the ventral surface; carapace with three ridges, becoming obsolete in adult...*Chelydra serpentina*

2 (1) Three or four supramarginal shields on each side just above the region of the bridge; orbit directed laterally; head covered with symmetrical plates; tail with many small scales on the ventral surface; carapace with three very strong, persistent ridges or keels ....*Macrochelys temminckii*

KEY TO THE FAMILY KINOSTERNIDAE IN ILLINOIS

1 (4) Humeral scutes triangular; plastron quite large, nearly filling the aperture; little cartilage between plastral elements; lobes of plastron of approximately equal length....Genus Kinosternon. (2)

2 (3) Size large; carapace flat; ninth and tenth marginals elevated ....*Kinosternon flavescens*

3 (2) Size small; carapace arched; only tenth marginal elevated.......... ....*Kinosternon subrubrum subrubrum*

4 (1) Humeral scutes rhomboidal; plastron narrow, not nearly filling aperture; interpectoral suture about equal to interhumeral; posterior lobe of plastron longer than the anterior lobe, and truncate, the angles not rounded; much cartilage between the plastral elements.................................Genus Sternotherus. (5)

5 (6) Carapace without a vertebral keel in the adult and without imbricated scutes; head with lateral yellow stripe back of the eye ....*Sternotherus odoratus*

6 (5) Carapace with a vertebral keel and imbricated scutes; head without lateral stripes; spotted........................*Sternotherus carinatus*

KEY TO THE FAMILY TESTUDINIDAE IN ILLINOIS

1 (6) Plastron with transverse hinges..................................(2)

2 (5) Beak hooked; shell high and convex; bridge rudimentary or absent; plastron with posterior notch; no bony temporal arch. Genus Terrapene..(3)

3 (4) Carapace with low vertebral keel; no trace of a bridge; posterior lobe of plastron broader than anterior; plastron hermetically closing the shell; median suture nearly straight, slightly if at all sinuous..............................*Terrapene carolina carolina*

4 (3) Carapace without a trace of a vertebral keel; a rudimentary bridge present; plastron not hermetically closing the shell; both plastral lobes of approximately equal width...............*Terrapene ornata*

5 (2) Beak without hook; shell somewhat depressed; bridge narrow but distinct; a bony temporal arch present.............*Emys blandingii*

6 (1) Plastron without transverse hinges..............................(7)

7 (14) Carapace without a vertebral keel...............................(8)

8 (9) Carapace relatively high, globular, the lateral marginals practically vertical; axillaries and inguinals small and rudimentary; plastron widely but shallowly emarginate; carapace with round yellow dots...*Clemmys guttata*

9 (8) Carapace much depressed, the lateral marginals about 45° with the vertical; plastron without ligamentous connection with the carapace; axillary and inguinal elements large; posterior margin of plastron truncate or very slightly emarginate............... ....Genus Chrysemys. (10)

10 (13) Plastron yellow or orange, with symmetrical dusky markings.......(11)

11 (12) Plastron with dusky central area, this not radiating out along the sutures...............................*Chrysemys picta marginata*

12 (11) Plastron with symmetrical central markings covering most of it, radiating out along the sutures................*Chrysemys picta bellii*

13 (10) Plastron yellow or orange, without dusky central markings; costal and vertebral shields alternating...........*Chrysemys picta dorsalis*

14 (7) Carapace with a vertebral keel; posterior margin of the plastron deeply notched...(15)

15 (18) Keel tuberculate and conspicuous..............Genus Graptemys. (16)

16 (17) A triangular or comma-shaped yellow spot behind the eye; second and third vertebral scutes convex before the tubercle; head large; alveolar surface of jaws greatly expanded...*Graptemys geographica*

17 (16) A boomerang-shaped yellow mark behind the eye, the median margins of which parallel each other on the dorsal side of the head and neck; second and third vertebral scutes concave before the tubercle; head relatively small; iris pale.. *Graptemys pseudogeographica pseudogeographica*

18 (15) Keel low and rudimentary.......................................(19)

19 (20) Carapace highly sculptured, with a series of conspicuous concentric rugae on each scute................*Clemmys insculpta* (hypothetical)

20 (19) Carapace not highly sculptured, without concentric rugae.......... ....Genus Pseudemys. (21)

21 (24) Alveolar surface of both jaws with a smooth ridge.................(22)

22 (23) Carapace with conspicuous transverse yellow stripes; a blood-red longitudinal stripe back of the eye; carapace emarginate anteriorly; plastron with a black spot on each scute................ ....*Pseudemys troostii* (formerly *elegans*)

23 (22) Carapace without yellow stripes; no blood red stripe behind the eye; plastron with much black mottling............................ ....*Pseudemys troostii* (melanistic males)

24 (21) Alveolar surfaces of both jaws with a tuberculate ridge.............(25)

25 (26) Lower jaw with smooth cutting edge; shell greatly depressed; alveolar surface of upper jaw narrower at symphysis than on sides; outer surface of mandible arched; shell elongate, narrow........ .... *Pseudemys hieroglyphica* (hypothetical)

26 (25) Lower jaw with serrate cutting edge; shell not greatly depressed; alveolar surface of upper jaw very wide all around; outer surface of mandible flat; shell broad...................*Pseudemys concinna*

KEY TO THE FAMILY TRIONYCHIDAE IN ILLINOIS

1 (2) Nostril circular, without a papilla projecting into it from the septum; snout very narrow, pointed; edge of upper jaw toothed posteriorly; nuchal margin of the carapace without conical tubercles; under surface of feet white or grayish, not mottled....*Amyda mutica*

2 (1) Nostril crescent-shaped, with a papilla projecting into it from the septum; snout not so narrow and pointed, being but little longer than the diameter of the orbit; edge of upper jaw not toothed posteriorly; nuchal border of carapace with a row of conical spine-like tubercles..(3)

3 (4) Light stripes on head uniting at base of snout; an abundant species ....*Amyda spinifera*

4 (3) Light stripes on head uniting just in front of the eyes; a rare or hypothetical species in southern Illinois only................... ....*Amyda ferox* (hypothetical)

FAMILY CHELYDRIDAE

Emydidae (part) Gray 1825; 1855; Bell 1828
Steganopodes (part) Wagler 1830
Emydae (part) Gray 1831
Elodites Cryptoderes (part) Dumeril & Bibron 1835
Chelydroidae Agassiz 1857
Chelydridae (part) Gray 1870; Cope 1872, 1882

External Characters.—Shell covered with epidermal shields. Carapace relatively small, the posterior border serrated; 25 marginals. Plastron with nine shields, very small and not nearly covering the soft parts; cruciform. The abdominal scutes do not meet on the mid-ventral line, the articulation between the pectoral and femoral elements intervening, and they are further separated from the marginal scutes by a series of (usually two) inframarginals. Neck completely retractile within the shell. Head very large and massive and incompletely retractile within the shell; jaws strongly hooked. Digits moderately long, the claws four or five, the outer toes being clawless. Tail long, at least half the length of the carapace, and highly crested dorsally. Chin with paired barbels.

Osteological Characters.—Temporal region incompletely roofed over; no parieto-squamosal arch present. Squamosal widely separated from the parietal. Cervical vertebrae: second and third opisthocoelous, the fourth amphycoelous; remaining procoelous. Caudal vertebrae: all oposthocoelous. Nuchal plate with very long costiform lateral processes extending ventral to the marginals. Pubic symphysis widely separated from the ischial.

Genus Macrochelys Gray

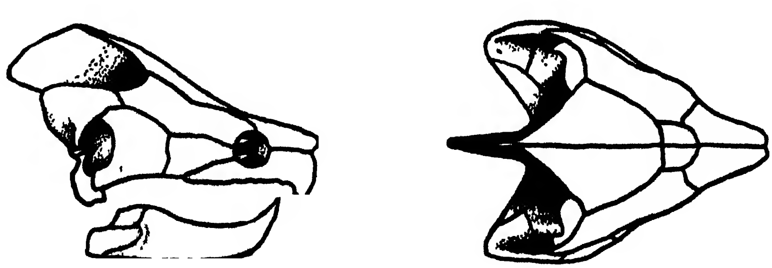
Chelonura (part) Holbrook 1840
Macroclemys Gray 1855
Macrochelys Gray 1855; 1870
Gypochelys Agassiz 1857
Macroclemmys Strauch 1862

Three or four supramarginal scutes interposed as extra plates between the marginals and the costals in the region of the bridge; carapace with three keels which are very prominent as persistent ridges. Head very large and massive, often wider than long, and with large plates dorsally; orbits directed laterally. Alveolar surface of the jaws very broad; jaw very strongly hooked at symphysis. Tail with three series of dorsal tubercles and with many small scales ventrally. A single species is known; this is by far the largest of the fresh-water turtles, attaining a weight of over 200 pounds.

Macrochelys temminckii (Holbrook)
(Alligator snapper; loggerhead)

Chelonura temminckii Holbrook 1840
Emysaurus temminckii Duméril 1851
Macroclemys temminckii Gray 1855
Macrochelys temminckii Gray 1855
Gypochelys lacertina Agassiz 1857
Macroclemmys temminckii Strauch 1862
Macrochelys lacertina Cope 1872

Description.—Carapace a wide oval, the width approximately two-thirds of the length; anterior margin practically smooth; posterior border with great tooth-like emarginations, these being associated largely with the posterior three marginals. Carapace with three great persistent ridges. The median keel is mid-dorsal down the middle of the vertebral scutes; it is present on each scute but becomes increasingly conspicuous toward the posterior end. On the last two vertebrals the keel arises from the anterior margin of the scute to a high, sharp posterior knob. The lateral keels lie along the dorsal medial edge of the costal scutes; these keels are, like the vertebral ridge, relatively low at the anterior end, and become increasingly prominent posteriorly. In the case of each costal scute the keel arises gradually from the anterior margin to a high, sharp posterior knob which drops abruptly to the edge of the scute. In many cases inconspicuous, low ridges tend to converge toward the tip of the knob. The first costal is roughly triangular; the remaining costals are rectangular. Three or four (rarely five) supramarginal scutes are located between the lateral margin of the anterior three costal scutes and the adjacent marginals; this is in the region of the bridge. Plastron small, narrow, cruciform, not nearly covering the soft parts. The plastral scutes are subject to great variation both in number and in relative position. All of the usual elements are present, but the abdominals are pushed out to form the major portion of the bridge, leaving the pectoral and femoral scutes in contact in the central area. Many small accessory scutes are interspersed throughout, and often there are one or two intergular scutes present. The head is enormously large and massive, the great masseter muscles building up a mound at the posterior region of the



Text-figure 6.—The skull of *Macrochelys temminckii*.

head from which the profile slopes in a concave curve to the protruding snout. The beak of the upper jaw projects far beyond the tip of the lower, and terminates in a sharp hook. The cutting edge of the upper

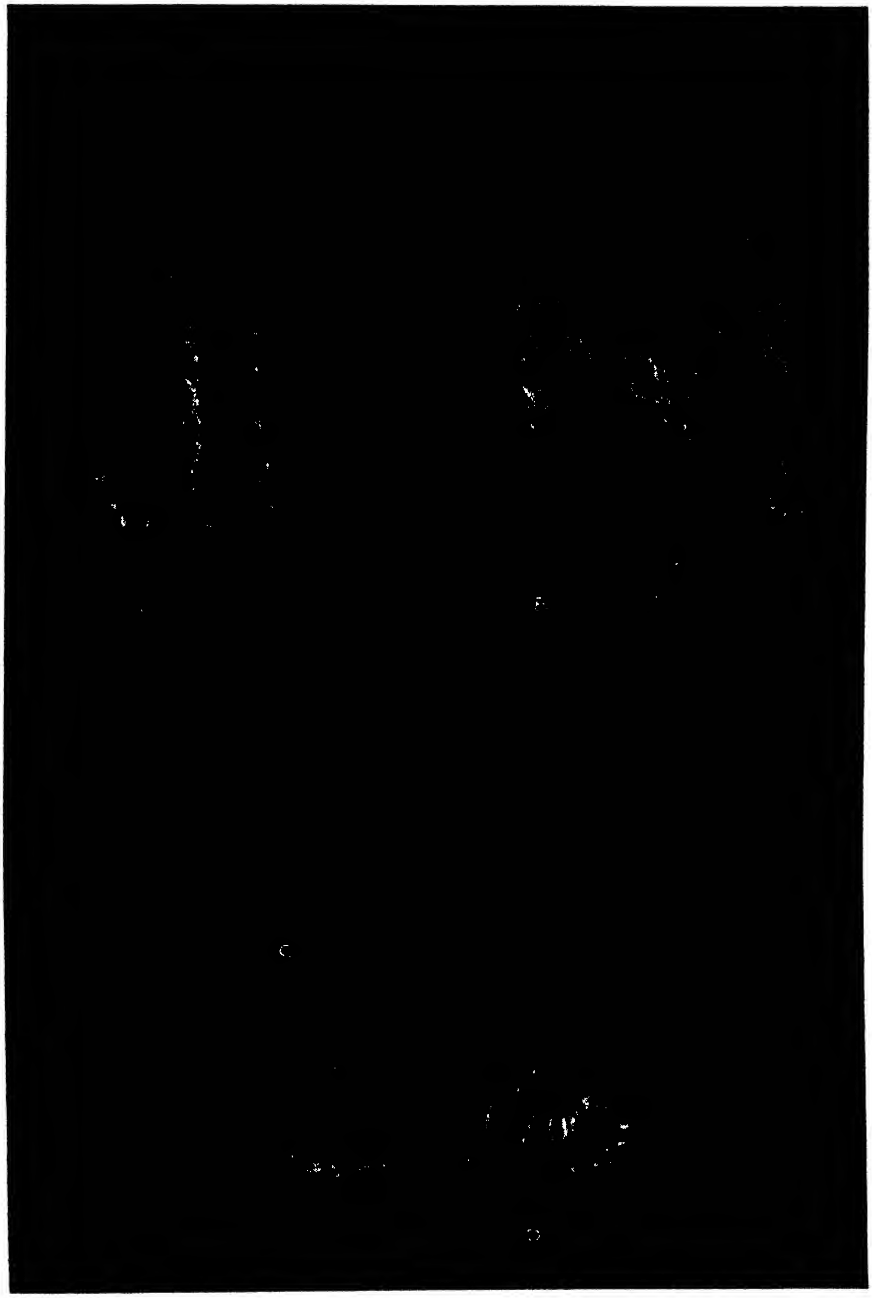


PLATE 1.—*Macrochelys temminckii: A,* Adult specimen weighing 103 pounds, dorsal view. *B,* Same individual, ventral view. *C,* Newly hatched individual (Agassiz specimen, courtesy of the Museum of Comparative Zoology), dorsal view. *D,* Adult, lateral view.

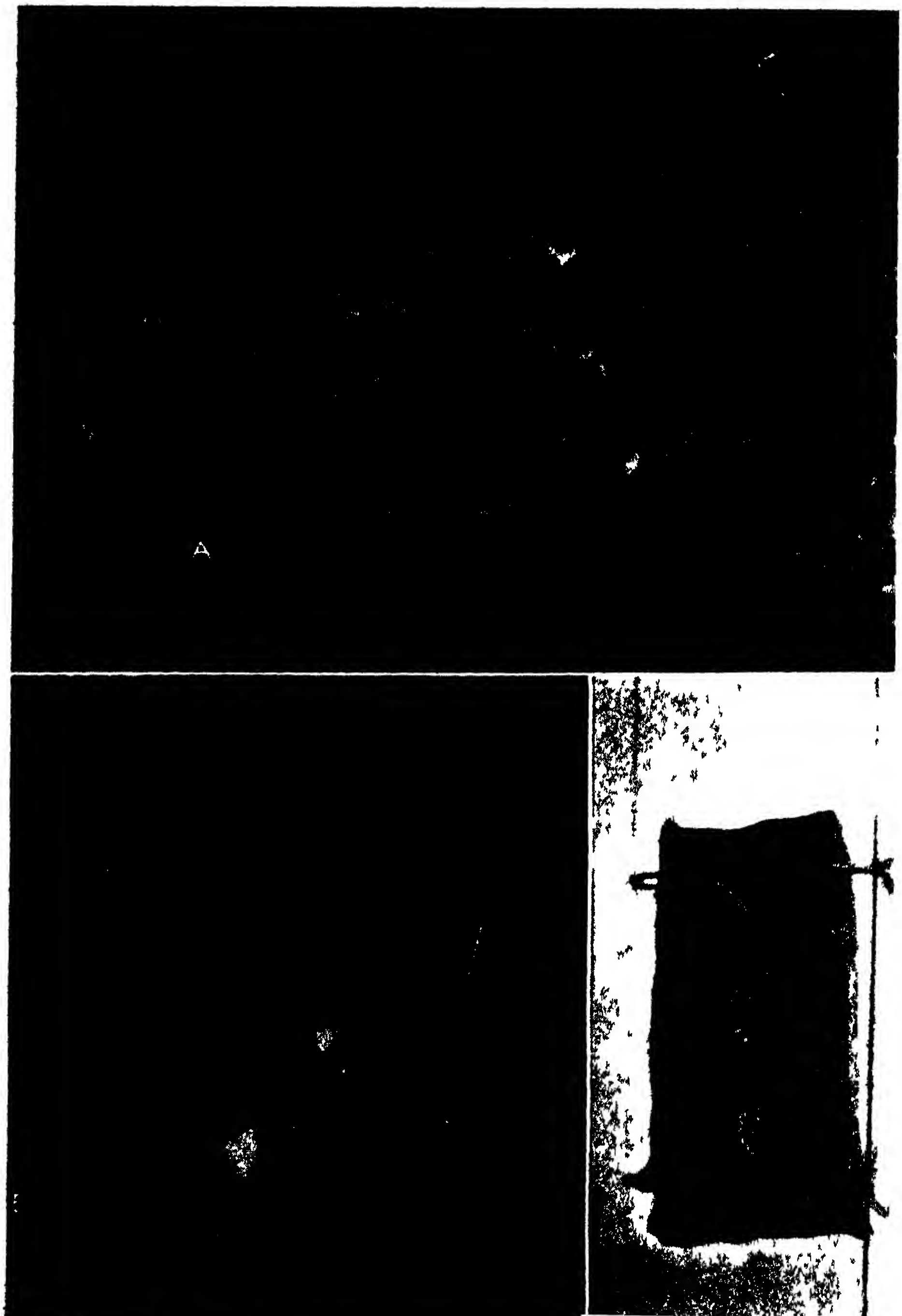


PLATE 2.—*Macrochelys temminckii: A,* Head study of a large adult. *B,* Mouth of the same individual, opened to show the "worm" on the tongue. *C,* Detail study of the "worm" on the tongue.

jaw rises just posterior to the tip of the beak, to descend again posterior to the orbit and rise again toward the angle of the jaw, giving it a wavy contour. The lower jaw is also strongly hooked, with a uniformly curved, sickle-like cutting edge. The top of the head is covered with rather large, imbedded, symmetrical plates. Neck relatively short, stocky; the skin bears many dermal tentacles of various sizes, some quite large and very conspicuous. These tentacles also adorn the chin. The tail is very long, about two-thirds the length of the carapace, and bears on its dorsal surface three low rows of tubercles; the ventral surface is covered with small, rounded scales. Limbs strong and very powerful; feet large; claws very strongly developed. Skin on the ventral surface tuberculate.

COLORATION.—Carapace dark brown, without any pattern and often covered with a thick growth of algae. Plastron a paler brown, also unmarked. Head, limbs, and tail dark brown, darker above than below. Head with inconspicuous darker brown spots which are usually quite indistinct. Iris black, with radiating brown or golden brown bars directed toward the pupil.

YOUNG.—The newly hatched young of the alligator snapper are extremely rare, and diligent search failed for a long time to reveal a single specimen in collections. At last, thanks to the kindness of Dr. Loveridge of the Museum of Comparative Zoology, the writer had the opportunity of examining and photographing the original specimen described by Agassiz (1857) and shown in the lithographs as figures 23-27, plate V, volume 2, of his work. The specimen is still in a perfect state of preservation. The newly hatched young exhibit all of the characteristics of the adult, reduced to miniature, and may be separated from the young of *Chelydra serpentina* by the same features. It differs from the adult in that the scutes of the carapace, especially the marginals, are greatly roughened by irregular corrugations and wart-like protuberances, and in the rather fancy, scroll-like formation of the first marginals. Furthermore, the skin of the young is far more highly ornamented with barbels than in the adult, these fairly covering the surface. The body proportions of newly hatched young are more nearly like those of the adult than in most other species of turtles, though the tail is relatively longer.

SEX DIFFERENTIATION.—There is an insufficiency of material available to warrant any generalizations on this subject, the two specimens which the writer handled both being females.

GEOGRAPHIC DISTRIBUTION.—The range of the alligator snapper is limited to the Mississippi River and its larger tributaries, and to a few other rivers flowing into the Gulf of Mexico from Texas to northeastern Florida. So far as the writer is aware, Quincy, Illinois, is the most northerly record of the species in the Mississippi, and it is very rare this

far north. It is a southern species, still rather common in the lower Mississippi River from central Arkansas to above the delta region of Louisiana; Hurter (1911) reports it from several localities in Missouri, but it is increasingly rare from central Missouri northward. One record outside of this circumscribed area occurs in Yarrow's *Check-list* (1882); here he records two specimens, U. S. N. M. #12345 from Northville, Michigan. A check on these specimens by Dr. Stejneger shows them to be incorrect. The National Museum never had any specimens of this turtle from Michigan, nor is any turtle listed under the number 12345.

ILLINOIS RECORDS.—There are but a few records of this huge turtle for Illinois, and it must be considered as a rare species within the state, for such a large animal is more than likely to attract attention if present in any numbers. Dr. H. Garman (1892) reports it from Quincy, Cairo, Grayville (Ridgway), and from Union County. The first two records, as well as the last, are for the Mississippi River; Grayville is on the Wabash River. Hay (1892) refers to Ridgway's Grayville specimen, and in his preliminary catalogue he refers to a specimen reported by Garman from "a short distance below Mt. Carmel." This is probably the Grayville specimen again. H. Garman (1889) says for the Quincy region: "This species is said by fishermen and sportsmen to occur here occasionally." To these published records the present writer adds a specimen (weight 96 pounds), from Murphysboro on the Big Muddy River, now in possession of the Southern Illinois State Teachers College at Carbondale, one specimen (weight 33 pounds) from Chester, on the Mississippi, and one (weight 103 pounds) from Metropolis from the Ohio River. The last two specimens are now in the department of zoology of the University of Illinois, in skeleton form. The distribution in the state is therefore within the Mississippi River and certain of its larger southern tributaries.

MAP. 1.—*Macrochelys temminckii.*

HABITAT.—The alligator snapping turtle is a highly aquatic species. It shows a marked preference for soft sandy or muddy bottomed streams in which it may partially bury itself in the loose débris. Because of its great size it rarely ascends small streams, and in consequence it frequents normally only the larger rivers tributary to the Mississippi River, as well as that river itself. It is distinctly not a lake species. A certain amount of vegetation is greatly desired by the turtle, as this both affords protection for it and serves as an attraction for its food. Deep holes in the river are its favorite resting places, and in time of danger the turtle retreats to the deepest, darkest hole available, where it remains for a long time almost immobile. It very seldom comes to land; this fact, coupled with its deep-water retreat, is responsible for so few being seen alive.

HABITS.—Although this turtle has been known to science since 1840, its habits and life history are still to a large extent shrouded in mystery. Other than a mention of its presence in a few local lists and a very few brief references to its habits, almost nothing appears in herpetological literature concerning this most interesting species.

The alligator snapper is by far the largest of the fresh-water species of North American turtles. Exactly how big it grows is unknown, but Agassiz reports having seen one alive that weighed around two hundred pounds; Hurter (1911) gives the measurements of one that weighed 148 pounds (see Table 2). An animal so heavy, so awkward, so cumbersome, and so massively armored is essentially slow and sluggish in its movements, and the alligator snapper is not an active species. It is content to lie amid the soft material of the river bottom, or among the waving strands of vegetation, or to wander slowly over the bottom, shifting its great bulk slowly forward as it walks. Usually the carapace is heavily overgrown with algae, and this green camouflage renders the animal inconspicuous in its natural haunts. Indeed, lying half buried in the dark muck, the strands of algae waving in the current, the turtle resembles a partially submerged rock.

TABLE 2.—MEASUREMENTS OF SPECIMENS OF *Macrochelys temminckii*
(Measurements in millimeters; weight in pounds)

Specimen No.	Carapace		Plastron			Head		Tail		Weight
	Length	Width	Length	Width	Depth	Width	Circumference	Total	A-T	
1	625	533	445	...	...	...	635	...	1525	148
2	625	500	425	...	...	...	612	...	...	115
3	610	462	400	388	186	200	627	333	1303	103
4	585	448	388	362	186	175	602	...	1292	96
5	567	437	...	...	...	...	...	...	...	80
6	453	342	303	305	175	123	385	238	822	33

The turtle is almost never seen on land, probably because its bulk and weight make for easier aquatic rather than for terrestrial locomotion. Captive specimens walk with a slow, hesitant gait when they walk at all, raising their great bulk clear of the ground during progression, but settling the plastron in contact with the ground as soon as progression ceases. H. Garman (1892) quotes Ridgway in regard to a specimen taken at Grayville, Illinois, which was "large enough to walk with a man standing on its back." The Metropolis specimen which the writer had for weeks in his laboratory and which weighed 103 pounds, was capable of walking all around the room with a man weighing 165 pounds standing on the shell, and seemed to do so with almost no extra effort.

Macrochelys temminckii is extremely ferocious. Possessed of a vicious temper, its ire is easily aroused and, once angry, the turtle is a creature to beware of. The neck is rather long and the bulky head comes shooting out from its concealment within the shell with astonishing speed, and with force sufficient to throw the entire animal into the air and forward in the direction of the strike. The masseter muscles are enormous, often so bulky, in fact, as to make the head wider than it is long; this is especially true in the very large specimens. The muscles pile up on top of the posterior region of the skull and give the face a sharply concave profile. The jaws are sharp-edged and strongly hooked, and when the masseter gets into action, the lower jaw comes up with the snap of a steel trap. The 103-pound specimen was able to cut through a broom handle with one snap of the jaws, the cut surface appearing as if it had been made by a sharp axe.

Almost the only account of the habits of this species is quoted herewith from Agassiz (1857); this account has reference to a specimen from Texas, but illustrates well the disposition of the animal:

I kept two for several years in my fish-pond. They became very tame, but finding they were eating my fish I shot one, and wounded the other with a fish-gig; but his sagacity prevented my capturing him. I fed the perch and minnows with bread, which the alligator turtle devoured greedily. One day, after he had eaten, he remained upon the rock where I had fed him, and which was only about a foot beneath the surface, where it shelved over water ten feet deep. A swarm of minnows and perch were picking up crumbs around him, apparently unconscious of his presence. His head and feet were drawn sufficiently within his shell to be concealed. His mossy shell could not well be distinguished from the projections of the rock on which he was lying in ambush. Several large bass were gliding around him, occasionally darting at the minnows. One of these, about fourteen inches in length, came within striking distance of his head, which he suddenly thrust out and fastened upon him, fixing his aquiline bill deeply into his side and belly. He immediately drew the fish under him, and, holding him down firmly to the rock with his forefeet, ate him greedily, very much as a hawk devours its prey. I drew out a large line and hook and baited it with a minnow, and threw it to him, determined to get rid of this skilful angler. He seized it; I gave a sharp jerk, and fastened it in his lower jaw. Finding him too heavy to lift by the hook upon a rock six feet perpendicular, I led him around to the lower end of the pool, where

the bank was low, and the water shallow. But, after getting him within a few feet of the edge of the water, he anchored himself by stretching forward his forefeet, and resisted all my efforts to get him nearer. He seemed to be in a furious rage, and, after several sharp snaps at the line, he broke the hook and retreated into the deepest part of the pool. I never could get him to bite at any thing afterwards; and, finding I had a design upon his life, he became very shy. I afterwards discovered him in deep water, eating the bread which fell from the shelving rock, on which he had fed for several years, but upon which he never ventured afterwards when I was near. I threw a gig at him, and fastened it in his neck; but, by a violent effort with one of his forefeet, he tore it loose and ran under the rock. I frequently saw him after his escape, but always in the act of retreating to his hiding-place, which was entirely inaccessible. I intended sinking a steel trap, baited with beef, to secure this sagacious old fellow, but my removal to the city probably saved his life. If these two turtles made a nest or deposited eggs while I had charge of them, I never discovered it. They kept all their love for one another, and their domestic affairs a profound secret from their master.

The mouth of the alligator snapper contains one of the most remarkable structures I am acquainted with, and one which deserves especial mention: this structure is the tongue. Dark yellow-gray in color, with vague, lichen-like patches and wrinkles over its surface, the tongue bears along its mid-dorsal line a white, fleshy object that strikingly resembles a whitish earthworm or slender grub. This object is elongated and tends to be round in cross-section. It is attached to the tongue over what is approximately the middle third of the length of this appendage, both ends being free. The anterior end is slightly expanded, thick, fleshy; the posterior end tends to taper and is more slender, terminating posteriorly in what looks like a small bunch of short, fleshy setae. A similar bristle arises from the mid-dorsal region of the attached third. An examination of the tongue shows that this strange object is controlled by a series of long, slender muscles which run to it just under the surface of the skin over the tongue. As to the function of this "worm" Ditmars (1908) has the only account of it:

With its colours in perfect harmony, it [the turtle] lies motionless on the soft bottom, ready to seize, with a lightening-like dart, the suspicious fish that comes its way. While thus resting it is able to entice its prey by a remarkable appendage attached to the inside of the lower jaw, close to the region of the tongue. [As a matter of fact, it is *on* the tongue.] This is a well-developed filament of flesh, white and distinct from the yellowish mouthparts and resembling a large grub to such a degree of nicety that the popular-minded observer, seeing the object in the reptile's mouth, would declare it to be the larva of some insect. More striking, however, is the reptile's power to keep this appendage in motion, giving it the aspect of crawling about in a small, circular course. With the mud-colored shell lying close to the bottom, the jaws thrown open to a great extent, this organ is put in motion. Every other portion of the creature is as motionless as a rock. In this position of rigidity the shell looks like a great round stone and blotches of fine, waving moss intensify the deception; the big head looks like another stone, beneath which there is a cavern and in this cavern crawls the white grub, to all appearances an object dear to the hearts of finny wanderers. But woe to the luckless fish that swims within reach of those yawning jaws.

A 33-pound specimen which the writer had in his laboratory gave just one very brief exhibition of the "crawling grub" act, which was exactly as Ditmars has described it. The control which the turtle can exercise over this remarkable appendage is nothing short of astonishing.

TEXT-FIGURE 7—The "worm" on the tongue of *Macrochelys tcmmıncku*

This organ is the more remarkable when one considers that there is nothing parallel to it in any other American turtle. The writer would suggest that an interesting problem lies here in working out the embryological development and origin of this unique structure. From the point of view of evolution and of adaptation, it is certainly interesting to note that the largest of all our fresh-water turtles, a species so large and cumbersome as to make fish-catching by dexterity out of the question, we find developed a fishing lure so highly perfected and so efficient as to make dexterity on the part of the turtle entirely unnecessary!

NESTING HABITS.—So far as I know, there is no account of the nesting habits in the literature, and the writer has failed entirely in obtaining any information on this phase of the life history. Mr. Viosca writes from New Orleans that he has never seen a nest, or taken either the eggs or young. The smallest specimen which his field collectors have brought in has a carapace length of 178 mm, and this specimen he kindly loaned me for measurements. Agassiz figures both the egg and the newly hatched young, but gives no account of either. I have no idea where the nest is made, or how it is dug, though probably similar in many respects to that of *Chelydra serpentina.* There is no information on the number of eggs laid, or on the season at which laying occurs, or on the period required for incubation. Thanks to Dr. Loveridge of the Museum of Comparative Zoology at Harvard, I was able to borrow, as I have said, the original material from which Agassiz figured the egg (Pl. 30,

fig. *D*) and the young (Pl. 1, fig. *C*). Search failed to yield any other egg or young of this species in any of the larger universities and museums, though perhaps some exist in institutions which I failed to contact. The alligator snapper is no longer nearly so common as it was a decade ago, and it is highly desirable that someone who has the opportunity work out and contribute to science the life history—yes, and the embryology—of this great turtle which seems to be doomed in the not far distant future to extinction.

EGGS.—The eggs are perfect spheres, covered with a hard, smooth shell of fine texture and without a glaze. They are, naturally, the largest eggs laid by our North American turtles. The egg figured by Agassiz, the photograph of which appears in this monograph, measures 36 mm in diameter.

FOOD HABITS.—With such jaws as this turtle possesses, one would assume without any further evidence that the alligator snapper is carnivorous. Such proves to be the case. The staple diet consists of fish, and they will apparently eat any species of any size which comes within catching range. I fed a sucker weighing a trifle under two pounds to the 33-pound turtle I had in the laboratory. The turtle watched the activities of the fish for about five minutes, never taking its little eyes off the prospective victim. Then with a sudden projection of the head, the jaws closed on the side of the fish near the tail, severing completely the latter appendage and taking a slice of sucker as cleanly and neatly as if done with a sharp carving knife. This the turtle swallowed quickly, using the front foot to assist the morsel into the mouth. The remaining part of the fish was pulled apart as Agassiz has described. No doubt they would eat almost anything alive that came within reach, whether it be fish or mammal, but there is no evidence of a scavenger habit. In captivity they show a marked liking for bread and raw hamburger. Although other turtles of various pond species were kept in the same aquarium, the alligator snapper never troubled them, though they climbed and roosted all over it constantly.

ECONOMIC IMPORTANCE.—So far as Illinois is concerned, the alligator snapper has little economic importance, due to its rarity. The meat is dark and strong, and has a rather offensive musky odor which might interfere somewhat with its palatability. Clark and Southall (1920) say: "It is especially abundant in the swamps of Louisiana, where an active fishery is carried on at certain seasons. It reaches an immense size. Its sale is confined chiefly to southern markets. As it is too large to ship in barrels, it is prepared for shipment by drilling holes with a breast drill through the edge of the upper and lower shells on each side of the neck and feet, running wires through and fastening it so that the head and legs can not be protruded."

PARASITES.—The leech *Placobdella parasitica* is common on this turtle. Of endoparasites, the nematode *Zanolophorus* sp. is usually abundant in the large intestine, over 250 having been taken from one specimen. Of trematodes, *Lophotaspis intenora* Ward and Hopkins 1931 has been taken in the Arkansas specimen, and *Distomum* sp. in the form of very immature specimens. An undetermined Linguatulid was found in the large intestine.

GENUS CHELYDRA SCHWEIGGER

Chelydra Schweigger 1814	Saurochelys Latreille 1825
Chelonura Flemming 1822	Cheliurus Rafinesque 1832
Rapara Gray 1825	Émysaurus Duméril & Bibron 1835

No supramarginal scutes between the marginals and costal scutes in the region of the bridge; orbit directed outward and upward; head covered with skin, not with symmetrically placed plates; tail with two rows of large scales ventrally; carapace with ridges fairly prominent in young specimens, becoming obsolete in large individuals; jaws moderately hooked.

Chelydra serpentina (Linnaeus)

(Snapping turtle; mud-turtle; hard-shelled turtle)

Testudo serpentina Linnaeus 1758	*Chelonura serpentina* Flemming 1822
Chelydra serpentina Schweigger 1812	*Rapara serpentina* Gray 1825
Chelydra lacertina Schweigger 1814	*Emysaura serpentina* Duméril & Bibron 1835
Emys serpentina Merrem 1820	*Chelydra emarginata* Agassiz 1857

DESCRIPTION.—The carapace is broad and depressed, not much longer than it is wide. It is higher toward the anterior end than in the posterior region, and the anterior margin is smooth and entire while the posterior border is coarsely and conspicuously serrated. The vertebral scutes are all rectangular, the first approaching a square. The anterior and posterior borders of the second vertebral scute are approximately equal in length, but the posterior margins of the third and fourth vertebrals are shorter than the anterior faces. In the case of the last vertebral scute the reverse is true: the anterior border is much shorter than the posterior. A vertebral keel is present in immature specimens, though no trace of it is to be found in mature individuals. The first costal is triangular; the remaining rectangular, the second being slightly the largest of this series. In young snappers and individuals approaching full growth there is a tendency toward a costal keel, which is very pronounced in the young and increasingly inconspicuous in older individuals until in fully adult turtles this keel is also absent. This costal keel, when present, arises gradually from the anterior margin of each costal scute, coming to a blunt point near the posterior margin. The marginals are 24 in number exclusive of the nuchal, which is well developed and costiform, extending long lateral arms under the anterior marginals. There are no supra-

marginals present as in *Macrochelys temminckii.* The serrations of the marginals are confined to the posterior three pairs for the most part, and there is a deep, curved notch between the caudal marginals. The plastron is very small and cruciform, leaving most of the soft parts of the ventral surface of the body exposed. The scutellation of the plastron is very definite and does not show the variation and eccentricities exhibited in the alligator snapper. Two interpretations exist for the condition found in the plastron: one holds that the anterior scutes are the humerals, the gulars being absent. This leaves an extra, elongated scute to form the

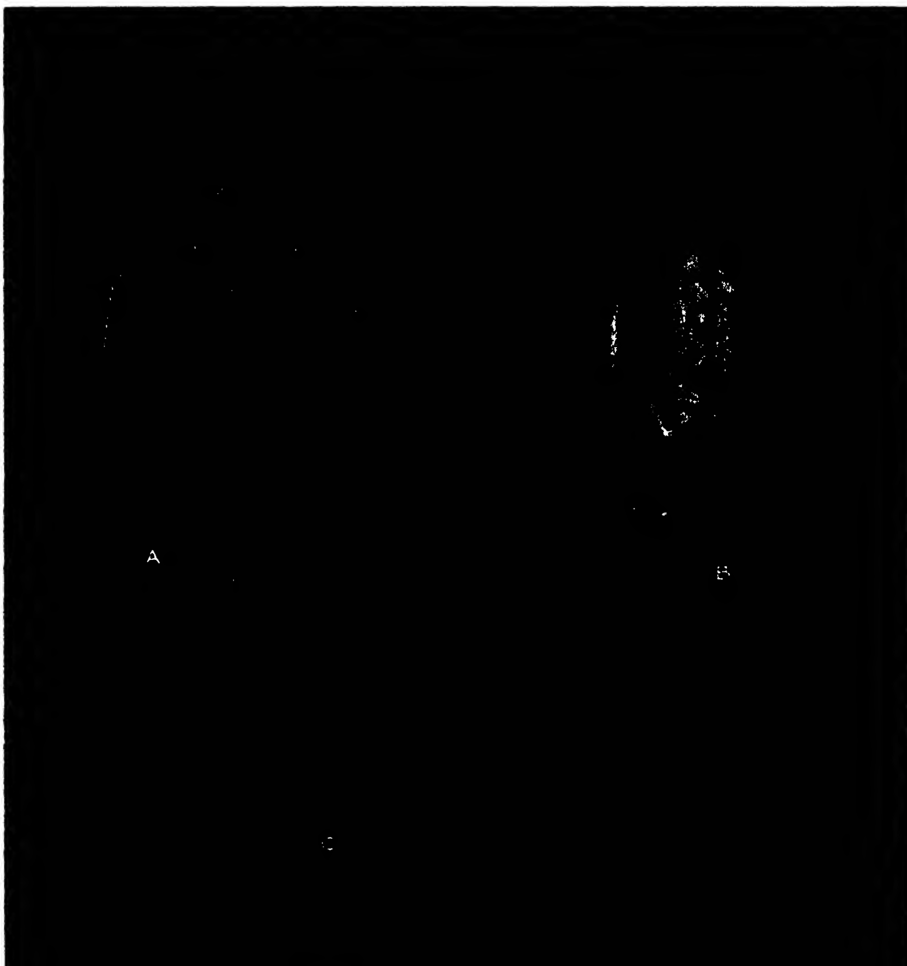


PLATE 3.—*Chelydra serpentina: A,* Adult, ventral view. *B,* Adult, dorsal view. *C,* Newly hatched young, dorsal view. *D,* Adult, lateral view.

major portion of the bridge. The second explanation is that the anterior plates are the gulars, in which case this extra plate becomes the displaced abdominal. The latter seems to the writer to be the correct interpretation of the situation. This elongated abdominal, then, is separated from the marginals by usually two inframarginal scutes, and the axillaries and inguinals are very small and inconspicuous. The pectoral scutes are the largest of the series. The head is large, triangular, and flattened dorsally. It is covered with skin and does not have the bony plates characteristic of the alligator snapper, though the ridged surface of the parietal, frontal, and postfrontal bones of the skull give the top

TEXT-FIGURE 8.—The skull of *Chelydra serpentina*

of the head a roughened appearance. The snout is pointed. Both jaws have a median tooth, posterior to which the cutting edge of the upper jaw is practically straight, though both jaws are strongly hooked at the symphysis. The orbits are directed outward and upward. The posterior portion of the head bears wart-like tubercles which increase in number and in prominence down the neck, and which are more numerous on the ventral surface. A pair of small gular barbels is located at the tip of the chin. Fore and hind limbs strong and powerful and covered with tubercles which are more prominent on the ventral surface. The anterior face of the fore limbs with strong, overlapping sharp-edged scales. The digits are fully webbed. Fingers five in number, each bearing a coarse, strong claw; toes also five, the fifth, however, being rudimentary and without a claw. The tail is long and powerful; it is covered on the ventral surface by two rows of small scales, and bears a median dorsal row of horny tubercles, each with a bony core, and on each side a row of much smaller wart-like projections.

COLORATION.—The carapace varies from olive brown to rich mahogany brown which in old individuals is often concealed beneath a thick growth of algae. In old specimens the carapace is without markings, though in immature specimens there often shows a series of radiating black lines which focus at the apex of the costal and vertebral knobs. The plastron is plain, dull yellow, or buff. The soft parts are

dark brown, darker above than below, the ventral tubercles tending to be light in color. The jaws are often streaked with black.

Young.—Young specimens tend to be lighter and brighter in color than mature ones. The small snappers are very rough dorsally and show three conspicuous tuberculate ridges or keels on the carapace which grow less conspicuous as the animal matures. All keels finally disappear. The tail is much longer, proportionately, in young snappers: in newly hatched young the tail at least equals the length of the carapace, while in two-thirds-grown individuals it equals approximately two-thirds the length of the upper shell. In young individuals the color markings of the carapace are much more conspicuous, and the top of the head, eye-lids, and jaws show dark brown mottling and streaking.

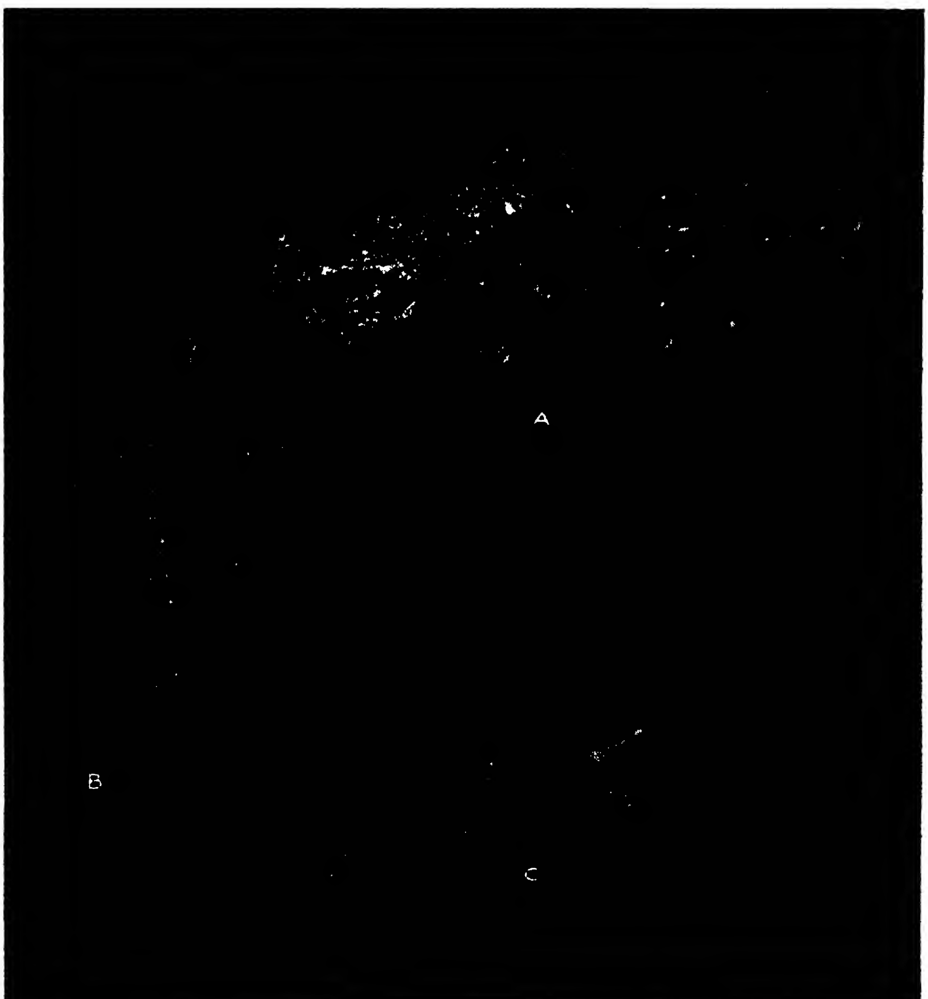
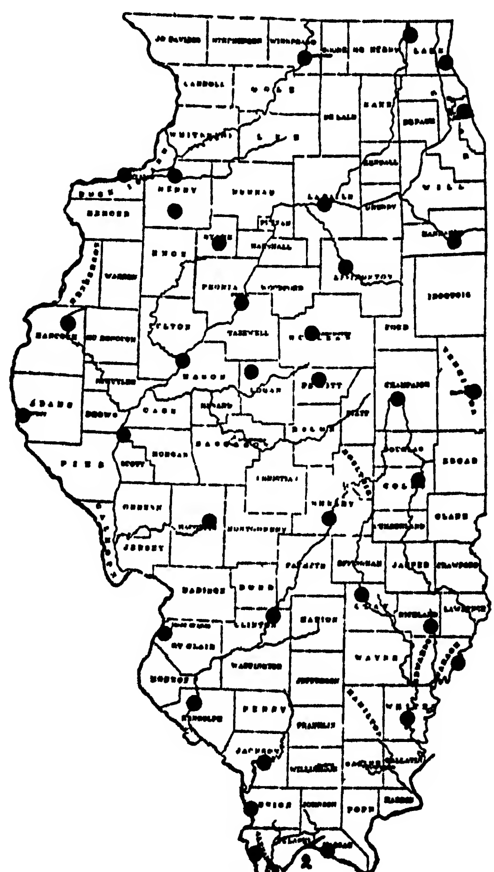


Plate 4.—*Chelydra serpentina: A,* Head study of a large adult. *B,* Immature individual, four inches long, dorsal view. *C,* Lateral view of the same individual.

Sex Differentiation.—The anus of the male is nearer to the tip of the tail than it is in the female.

Distribution.—The common snapping turtle, *Chelydra serpentina,* has a very wide range of distribution. From central Canada (I have found the species nearly to Hudson Bay) the range is known to extend to the Gulf of Mexico and southward almost to the equator. From the east the range extends from Nova Scotia and the Atlantic seaboard westward to the Rocky Mountains. It is reported as common in South Dakota and Iowa. In Colorado it has been taken at least as far west as Boulder and vicinity. In Texas its range covers at least the eastern half of the state, and from here it is common eastward through Oklahoma, Kansas, Arkansas, and Louisiana. A closely allied species, *Chelydra osceola* Stejneger, is found in central and peninsular Florida.

Illinois Records.—*Chelydra serpentina* has a state-wide distribution in Illinois. Yarrow (1882) reports specimens in the National Museum (#9724, 12066) from Mt. Carmel; H. Garman (1892) from Nippersink Lake in Cook County; Green River at Geneseo; Quincy; Peoria; Havana; Normal; Champaign; Union County and Mt. Carmel. Hurter (1911) has specimens from St. Clair County, and Gaige (1914) from Richland County. Weed (1923) reports the snapper from Meredosia, and Hankinson (1917) reports it at Charleston. The Field Museum has specimens from Clinton (#481), Havana (1758, 2466), Fox Lake (1906), Olive Branch (2179, 2217), Meredosia (3291), and Highland Park (8108). The writer has examined specimens from the following localities: Havana, Peoria, Quincy, Champaign, Meredosia, Clinton, Danville, Robinson, Middleton, Rockford, Rock Island, Pontiac, Carlinville, Carthage, Shelbyville, Louisville, Evansville, Carlisle,



Map 2.—*Chelydra serpentina.*

Murphysboro, Carmi, Kankakee, Ottawa, Wyoming, Kewanee, Metropolis, and Horseshoe Lake in Alexander County.

HABITAT.—The common snapper, *Chelydra serpentina,* is almost entirely an aquatic species. Its favorite environment is a stagnant pond or weed-grown lake or river. Amid the vegetation the turtles prowl for their food, or lie half buried in the soft mud bottom which characterizes waters of this type. They inhabit rivers of any size; they are common in the Mississippi, and I recently caught two that weighed over ten pounds apiece in the Embarrass River in Champaign County, where that stream is less than two feet wide. Though they prefer ponds and weeds, they are, nevertheless, sometimes found in clear streams and crystal lakes, for these turtles are great wanderers. While not at all abundant in the region of central Ontario, I have found the snapper in the rocky, inhospitable, cold lakes of that province. During the summer, and especially at the egg-laying season, the snapper is wont to wander far afield, leaving the water and traveling into the grassy fields or into plowed or sandy areas. During the seasons of excessive drought, they leave their native ponds as they dry up and with apparently unerring instinct travel overland to more congenial and habitable regions.

HABITS.—Though very aquatic, the snappers are less able swimmers than other equally aquatic turtles such as the soft-shelled species of the genus Amyda. Their great bulk and weight make for poor swimming, and these turtles turn but seldom to this mode of progression. They prefer to travel by slowly and laboriously walking along on the bottom. They are often seen floating lazily near the surface of the lake, the shell entirely beneath the surface film, but the nostrils and ever-watchful eyes protruding above it. Here they paddle slowly and aimlessly about, or are content just to float and do nothing at all. When disturbed, or when they are convinced that they have been observed, the head is slowly and carefully withdrawn, so slowly as to leave hardly a ripple on the surface to disclose their whereabouts. Once out of sight, they swim to the bottom and there conceal themselves.

On land the snapper is slow and awkward in its movements. It is incapable of rapid locomotion because of its bulk but, having few enemies outside of man, it has little need for rapid locomotion. When walking through a swamp or over soft ground it leaves a very characteristic trail, consisting of a slender somewhat undulating line made by dragging the heavy tail over the ground, on each side of which may be seen the impression of the feet. So heavy are the larger turtles that these tracks are often very conspicuous. When frightened or disturbed while on land, the turtle does not withdraw within its shell, but with jaws agape, prepares for action. It follows every motion of the intruding party, pivoting

awkwardly on its hind feet if necessary so as to keep its powerful jaws always pointed at the moving danger. It stands its ground without, apparently, the slightest idea of a passive retreat. If teased, its irascible temper breaks all bounds, and the turtle flings itself violently at the intruder with such force as to carry it clear of the ground and considerable distance forward, the jaws snapping shut as the head shoots out. Once it fastens its jaws on an object, the snapper is extremely reluctant to let go again, and may be lifted clear of the ground and carried off if it makes contact with a stout stick. If unsuccessful after several attempts to reach the object of its wrath, the turtle becomes sullen and withdraws its head within the shell, keeping, however, the jaws fully open and making occasional half-hearted but dangerous lunges. The withdrawal of the head into the shell is accompanied by a hissing sound which is produced by the sudden expelling of breath as the head is violently jerked back and the capacity for storing air is lessened. Under circumstances producing anger, the snapper emits a strong, musky odor which in large specimens is both disagreeable and penetrating.

The snapper obtains its food either by waiting for it to come within range of its jaws, or by stalking it. In the first case the turtle, partially concealed by its growth of algae and half buried in the mud, waits patiently for a fish or crayfish to approach; then, with a lightning strike of its head, it seizes its victim. When stalking its prey the turtle advances so slowly that its movement is scarcely discernible. The neck is extended and rigid; the feet are lifted and advanced with all the care and caution practiced by a setter advancing upon a covey of quail. When just within reach of its victim the jaws are slowly opened. Then the strike.

The turtle is a voracious feeder, and from the time it emerges from hibernation until that condition is resumed, it feeds ravenously. Thus, as the summer wears on, we find the snapper "putting on" weight and becoming fatter and fatter until it becomes positively corpulent, great rolls of fat bulging over the edges of the all too small plastron. This stored material tides the animal over the winter months of its inactivity.

When fall comes the snapper is among the earliest species of turtle to go into hibernation. During the summer this species leads a more or less solitary existence, each individual going its own way, and while many snappers may be found in a suitable pond, the species is distinctly unsocial in its habits and not gregarious. With the approach of the cooler weather of October, and the ensuing drop in the temperature of the water, the snappers begin to congregate in places suitable for hibernation. At Meredosia, on the Illinois River, hibernation begins about the middle of October, and by the end of that month the last snapper has, as a rule, disappeared. A majority of the snappers go down into the mud at the

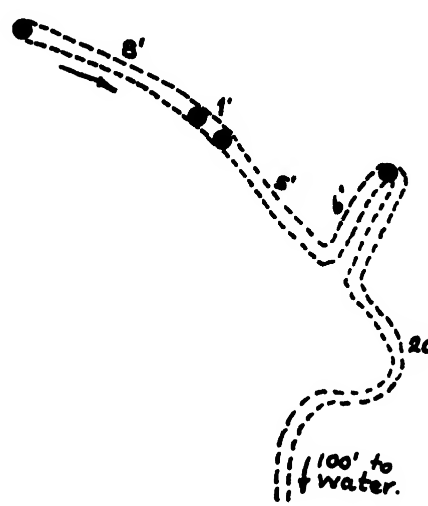
bottom of the pond or slough, usually to a depth of ten to twelve inches, where they "mud up" for the winter. Another favorite place is the burrow of the muskrat (*Ondatra zibethica*). In these burrows snappers congregate in great numbers. Clark and Southall (1920) report as much as five tons of snappers taken from such burrows at Muscatine, Iowa, in a single season. Twenty-six large snappers were taken from a single burrow, and from another runway 1420 pounds of snappers were removed. Yet another favorable site for hibernation is beneath logs partially buried in wet mud. Once they have turned in for the winter the snappers do not come out again until spring, usually about the middle of May. It is while the turtles are in hibernation that the market catches are made by turtle hunters. The method used is that of probing with a sharp stick until a turtle is located, the creature then being hauled out with an iron hook fixed at the end of a long stick. The gregarious wintering habits make wholesale catches possible, for where there is one turtle there usually are more.

In captivity the snapper is sullen and always dangerous to handle. While they eat well they never become tame as do many of the smaller species. In spite of prolonged "hunger strikes" during which they may go for months without eating, the turtles live well under artificial conditions, and may be kept for years in good condition even in crowded quarters.

NESTING HABITS.—In mid-June the spirit to lay seizes the snappers and the female forsakes her accustomed watery environment to search for the right spot to deposit her eggs. I have trailed snappers for more than half a mile from water during the egg-laying season. In regard to the site chosen for the nest, I cannot refrain from inserting the admirable account by Professor Jenks, which Babcock (1919) quotes:

> Leaving my horse unhitched, as if he, too, understood, I slipped eagerly into my covert for a look at the pond. As I did so, a large pickerel ploughed a furrow out through the spatterdocks, and in his wake rose the head of an enormous turtle. Swinging slowly around, the creature headed straight for the shore, and without a pause scrambled out on to the sand. She was about the size of a big scoop-shovel; but that was not what excited me, so much as her manner, and the gait at which she moved; for there was method in it and fixed purpose. On she came, shuffling over the sand toward the higher open fields, with a hurried, determined seesaw that was taking her somewhere in particular, and that was bound to get her there on time. I held my breath. Had she been a dinosaurian making Mesozoic footprints, I could not have been more fearful. For footprints on the Mesozoic mud, or on the sands of time, were as nothing to me when compared with fresh turtle eggs on the sands of this pond. But over the strip of sand, without a stop, she paddled, and up a narrow cow-path into the high grass along a fence. Then up the narrow cow-path on all fours, just like another turtle, I paddled, and into the high, wet grass along the fence. I kept well within sound

of her, for she moved recklessly, leaving a trail of flattened grass a foot and a half wide. I wanted to stand up—and I don't believe I could have turned her back with a rail—but I was afraid if she saw me that she might return indefinitely to the pond; so on I went, flat on the ground, squeezing through the lower rails of the fence, as if the field beyond were a melon-patch. It was nothing of the kind, only a wild, uncomfortable pasture, full of dewberry vines, and very discouraging. They were excessively wet vines and briary. I pulled my coat-sleeves as far over by fists as I could get them, and with the tin pail of sand swinging from between my teeth to avoid noise, I stumped fiercely, but silently on after the turtle. She was laying her course, I thought, straight down the length of this dreadful pasture, when, not far from the fence, she suddenly hove to, warped herself short about, and came back, barely clearing me, at a clip that was thrilling. I warped about, too, and in her wake bore down across the corner of the pasture, across the powdery public road, and on to a fence along a field of young corn. I was somewhat wet by this time, but not so wet as I had been before wallowing through the deep, dry dust of the road. Hurrying up behind a large tree by the fence, I peered down the corn-rows and saw the turtle stop, and begin to paw about in the loose soft soil. She was going to lay. I held on to the tree and watched, as she tried this place, and that place, and the other place—the eternally feminine. But *the* place, evidently, was hard to find. What could a female turtle do with a whole field of possible nests to choose from? Then at last she found it, and whirling about, she backed quickly at it, and, tail first, began to bury herself before my staring eyes.



TEXT-FIGURE 9.—Showing the wandering of a female *Chelydra serpentina* in search of a nesting site; black dots indicate holes dug.

If the nest site be a vertical bank of soft material, the turtle backs into it, causing the loose material to fall upon her carapace until she may be completely hidden from view. When she comes out, climbing uphill to do so, the material on her back slides down into the hole and buries the eggs. If digging into a flat field, the hole is scratched out with the claws, the turtle backing into it as the digging progresses. The nest itself is a chamber considerably wider than the tunnel leading down to it from the surface, and is an expansion to one side of the axis of the tunnel. It often lies a foot below the surface, the angle of the tunnel being between 45° and 60° with the horizontal. In this subterranean chamber the eggs are laid, often in two or three layers, with no dirt between the strata. Occasionally odd nesting sites are chosen, such as the cinder area between the tracks of a railroad right of way, where I once saw one digging.

Eggs.—The snapping turtle usually lays her eggs early in the day and is seldom found laying after ten or eleven o'clock in the morning. These eggs are perfectly spherical and are covered with a tough, white shell. So strong is this shell membrane that the egg will bounce several times if dropped on a hard surface. In a fresh egg one pole is white, the other pinkish, and the egg contains a very large air chamber occupying nearly half the space within the shell. There is a great discrepancy in literature as to the number of eggs laid by a single female in her nest. Thus Surface (1908) says that "from twenty to one hundred may be laid in one nest, according to the size of the female," while Hay (1892) gives the number as "from 30 to 70." The writer doubts very much that these high numbers represent the egg complements of one female, since, after examining a great many female snappers, there is every evidence that the average number is far below this. From 20 to 30 eggs constitute a normal clutch, and when a much larger number is reported, the conclusion must be drawn that more than one turtle is responsible. Since the turtle has, at the time of laying her eggs, not only the eggs to be laid that season in her body but also the growing eggs for the succeeding season, care must be taken in counting the eggs in the body cavity not to confuse clutches which will mature during different years. In size the eggs measure about 33 mm on an average. The incubation period is not known. The young snappers extricate themselves from the egg by means of a tiny "egg tooth" on the tip of the snout, with which they pick away the shell.

Food Habits.—The common snapper is largely a carnivorous species A list of the animals upon which it normally preys would run through many of the classes of animals, both vertebrate and invertebrate, which are available for it to feed upon. Among the vertebrates, fish, frogs, tadpoles, salamanders, snakes, birds, and mammals are commonly found in the digestive system, while among the invertebrates, snails, insects, insect larvae, and crayfish are predominant. Fish and crayfish probably make up the bulk of the food, because both of these animals are common in the habitat selected by the snapper. Aside from these items, the turtles are scavengers and will clean up any carcasses or meat thrown into the water in which they live. Thus I have found bones of animals such as dogs, cats, and rabbits in the stomach, as well as pieces of bones of much larger animals showing the saw marks of the butcher. The marvel is how these great masses are eventually passed from the digestive system without tearing it to shreds. All food taken is swallowed under water and apparently the turtle is unable to swallow unless beneath the surface. Young ducks are often captured, the turtle grabbing them by their submerged legs and dragging them under water, there to drown and be

pulled to pieces by the hawk-like beak. In spite of their preëminently carnivorous habits, occasional individuals are found whose stomach is full of grass, leaves, and other vegetable matter. Sometimes this represents aquatic vegetation, but more often terrestrial plants. In other words, when the turtle is out of water it cannot obtain its usual animal food, yet it is adaptive enough to subsist on a vegetable diet. The young feed on insect larvae which they find buried in the mud.

ECONOMIC IMPORTANCE.—That the snapping turtle destroys a great many fish is a fact. The list of species identified includes such forms as the crappies, the sunfishes, perch, bass, suckers, carp, and a large variety of minnows. In spite of this, in many localities the species of fish eaten are of little or no economic importance to man. Along the Illinois River these turtles, caught in hoop nets, often destroy a considerable number of valuable fish before the fishermen arrive to take up the nets; also they are powerful enough in some cases to tear their way out of the net, leaving a fine exit for the captive fish. Their destruction of young ducks, both of domestic and wild species, is often serious. Since wild ducks and

TABLE 3.—MEASUREMENTS OF THE SNAPPING TURTLE, *Chelydra serpentina*
(Measurements in millimeters; weight in grams)

Specimen No.	Carapace		Plastron			Head	Tail		Weight	Sex
	Length	Width	Length	Width	Depth		Total	A-T		
1	232	187	160	156	94	50	171	156	2450	♀
2	327	271	231	230	122	71	270	190	5906	..
3	59	50	40	36	28	14	55	45	58	..
4	320	272	224	220	110	62	245	195	5783	..
5	202	170	144	217	85	45	170	139	1606	..
6	272	231	197	...	100	61	200	172	2521	..
7	300	256	219	...	...	...	275	...	....	..

birds of similar habits tend to breed in the proximity of weedy lakes and take their broods of young into such ponds immediately after hatching, and since such ponds form the natural habitat of the snapper, this depredation is greater than it would at first appear. In Ontario I have seen snappers catch young loons.

Set against these items which must be checked as detrimental from the point of view of man, we have the scavenger habits of the turtle and its economic importance as a food animal. The snapper will eat any dead animal matter it comes across—including fish left on a stringer in the lake by careless fishermen. Since their capacity seems almost unlimited, they play an important part in the "clean-up" of waters polluted by waste material of this nature. As food for man the snapper affords

an easily obtained and usually available supply of wholesome, nutritious meat. The meat is likely to be rather "strong" and, so far as I personally am concerned, one must acquire a taste for turtle meat. A large individual yields a surprising quantity of flesh: one can figure on obtaining an amount of eatable meat equal to about one-half of the total weight of the turtle. The market value is about twenty-five cents a pound, dressed, and the turtle, therefore, becomes one of the cheapest of the available meats. In spite of this fact, the market for snappers has steadily decreased during the last decade.

PARASITES.—The snapper is almost always heavily infested with the leech *Placobdella parasitica,* and I have removed 44 specimens from a twelve-pound turtle taken at Meredosia. The leeches congregate especially in the angles under the fore and hind limbs, about the anus, and around the eye sockets. Nematodes of the species *Spironoura chelydrae* are often extremely abundant in the intestine. The trematode *Allossostoma parvum* Stunkard has been taken from snappers at Urbana, as has the trematode *Camallanus trispinosus* (Leidy).

MISCELLANY.—There is on hand an unusual carapace of *Chelydra serpentina,* taken from the Rock River at Rockford in 1927, now the property of the State Natural History Survey. This carapace presents a most weird appearance. In the first place, it is highly domed like a derby hat; in the second place, it is wider than it is long. It is perfectly formed as to osseous elements and normal as to scutes, excepting only that the costal scutes are greatly elongated to compensate for the doming. The following measurements of the carapace are of interest:

	Freak	*Normal*
Length	221 mm	313 mm
Width	257 mm	256 mm
Height	128 mm	84 mm

Regarding this specimen, Dr. David H. Thompson of the Natural History Survey, who saw the turtle alive, writes: "This turtle was caught by some boys in the fishway of the Oregon dam on the Rock River in June, 1927. It was kept alive for several weeks at Rockford, where I saw it and had the opportunity of watching its unusual behavior. The head and legs were of a size in keeping with a very much larger individual. When it walked on land it did not drag its plastron on the ground as is usual, but walked upon its tip-toes, with the body carried two or three inches clear of the ground. This habit of walking, together with its very long legs and neck, gave it a very grotesque appearance."

FAMILY KINOSTERNIDAE

Kinosternon Spix 1824
Emydidae (part) Gray 1825; 1844; 1855
Steganopodes (part) Wagler 1830
Emydae (part) Gray 1831
Elodites Cryptoderes (part) Duméril & Bibron 1835
Cinosternidae Agassiz 1857; Cope 1882
Chersemyda (part) Strauch 1862
Chelydradae (part) Gray 1870

External Diagnosis.—Carapace elongate, oval, either highly convex or relatively flat; usually smooth, but keeled in one species; marginals 23 in number, not flaring. Nuchal scute small dorsally, but larger ventrally, underlying the adjacent marginals. Plastron moderately large, rounded anteriorly and either truncate or shallowly emarginate posteriorly. Dermal skeleton covered with epidermal scutes. Plastron with 10 or 11 scutes, the anterior pair coalescing into one in some species; anterior lobe movable upon a fixed central portion. Pectoral scutes widely separated from the marginals. Axillaries and inguinals, together with the wings of the abdominals, forming the bridge. Neck completely retractile within the shell. Head large, pointed, with a large rhomboidal plate dorsally and with a projecting snout. Lower jaw terminating in a sharp point. Eyes located well toward the anterior end of the head. Digits moderately well developed; webbed. Five fingers and four toes bearing claws. Tail terminating in a nail.

Osteological Diagnosis.—Plastron composed of eight bones, the entoplastron being absent. Nuchal plate produced into costiform processes underlying the marginals. Temporal region not roofed over; no parieto-squamosal arch present. Pubic-ischial symphyses in contact, separating two foramina. Phalanges with condyles. Caudal vertebrae procoelous.

Genus Sternotherus (Gray)

Sternotherus Gray 1825
Kinosternon (part) Spix 1824
Sternothaerus Bell 1825
Cinosternon (part) Wagler 1830
Staurotypus (part) Duméril & Bibron 1835
Kinosternum (part) LeConte 1854
Armochelys Gray 1855
Cinosternum Agassiz 1857
Ozotheca Agassiz 1857
Goniochelys Agassiz 1857

Plastron narrow, approaching cruciform; posterior lobe not more than one-half the width of the aperture and longer than the anterior lobe; lobes but slightly movable and incapable of closing the aperture. Wings of abdominal scutes narrow, not grooved posteriorly; much cartilaginous material between certain plastral elements centering around the abdominals. Carapace highly arched or domed, unkeeled; first vertebral scute in the form of a long, narrow triangle.

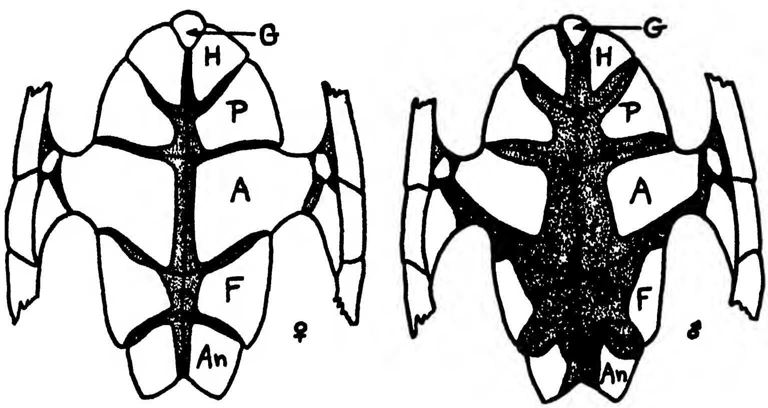
Sternotherus odoratus (Latreille)
(Musk turtle; stink-pot)

Testudo pensylvanica, B., Schoepff 1792
Testudo odorata Latreille 1802
Testudo glutinata Daudin 1802
Emys odorata Schweigger 1814
Terrapene boscii Merrem 1820
Terrapene odorata Merrem 1820
Cistuda odorata Say 1825
Sternothaerus odoratus Bell 1825
Sternothaerus boscii Bell 1825
Kinosternum odoratum Bonaparte 1830
Kinosternon odoratum Gray 1831
Staurotypos odoratus Duméril & Bibron 1835
Kinosternum guttatum LeConte 1854
Aromochelys odorata Gray 1855
Ozotheca odorata Agassiz 1857
Ozotheca tristycha Agassiz 1857
Goniochelys triquetra Agassiz 1857
Aromochelys guttata Strauch 1862
Aromochelys tristycha Strauch 1862
Cinosternum odoratum Boulenger 1889
Aromochelys carinata (part) Garman 1892
Aromochelys odoratus Davis & Rice 1883

Description.—Carapace long and somewhat narrow, widest posteriorly through the seventh marginal scute, the curvature being almost alike at the anterior and posterior ends. The shell is highly arched, rounded, and in old individuals smooth, but there is occasionally a faint trace of the vertebral keel which is prominent in young individuals. The nuchal scute is very small, hardly larger in the adult than in a newly hatched young. The first vertebral scute is greatly elongate, triangular, the apex pointing backward; the second, third, and fourth vertebrals are more or less hexagonal or shield-shaped, the fourth being the smallest of the series. The anterior margin of the last vertebral scute is approximately half as wide as its posterior margin. The costals are enormously large, covering the greater portion of the carapace, the posterior lateral angles of the first three curving backward. The marginals are elongate and narrow, with the exception of the last pair and the caudals, which two pairs are fully twice the width of the other marginals. The plastron is small, not nearly covering the soft parts, and is rounded anteriorly and truncate posteriorly. It differs from the plastron of other Illinois turtles in that the adjacent (paired) scutes do not touch each other, being separated by a cartilaginous mass of varying diameter. The single gular is very small; the humerals are small, the pectorals being about twice their size. The abdominals are by far the largest of the ventral scutes. The narrow bridge is formed by a small wing of the abdominal and the axillary and inguinal scutes which intrude themselves between the abdominals and the marginal plates so that these do not make contact. There is a movable transverse hinge between the pectoral and abdominal scutes, and a less movable hinge posterior to the abdominals. Head large, the snout projecting; the jaws are strong, the lower being hooked. Two, three, or four gular tentacles at the tip of the chin, and another pair, more widely separated, farther back on the neck, which is very long.

The feet are large, the toes webbed; digits 5-4, the claws small and short. The anterior border of the front legs bears three elongate transverse scales; the posterior limbs exhibit a small series of similar scales on the heels. The skin is everywhere covered with small fleshy papillae.

COLORATION.—Carapace brownish olive or dark "horn" color above, darkest toward the mid-dorsal line and shading into yellowish on the marginals. Usually uniform in color, but sometimes exhibiting dark transverse lines especially on the costals. Often the carapace is so overgrown with algae as to completely obscure the markings. Plastron yellowish, sometimes with indications of dark brown blotches or lines



TEXT-FIGURE 10.—Plastron of male and female *Sternotherus odoratus* to show sex variation in the amount of cartilage (stippled). *A*—abdominal; *An*—anal; *F*—femoral; *G*—gular; *H*—humeral; *P*—pectoral.

along the sutures, the fleshy or cartilaginous parts between the scutes with a decidedly pink tint. Head and neck dark olive. A short yellow stripe extends along the edge of the snout to the anterior margin of the eye and continues vaguely posterior to it, to terminate in an irregular yellow spot above and behind the ear. A second stripe begins just ventral to the nostril and extends backward along the side of the neck, passing below the tympanum. The extent of the first mentioned stripe shows great variation, and the second stripe may occasionally be absent. The lower jaw is mottled with yellow. The papillae are for the most part yellow or orange against the dark olive of the skin.

YOUNG.—In young specimens just hatched (carapace length 23 mm), the carapace is rough and exhibits three distinct and conspicuous keels: one mid-dorsal and extending down the vertebral scutes, and a pair of lateral keels along the upper third of the costal scutes. In arrangement these are not unlike those of the young snapping turtle *Chelydra serpen-*

tina; indeed, young *Sternotherus odoratus* are more often than not confused with this species. The surface of the carapace is roughened by tiny irregularities which disappear with age, giving it a sandpaper-like appearance. Carapace highly arched and nearly black in color. Plastron grayish, mottled with pale yellow; a pale yellow spot on the mid-ventral

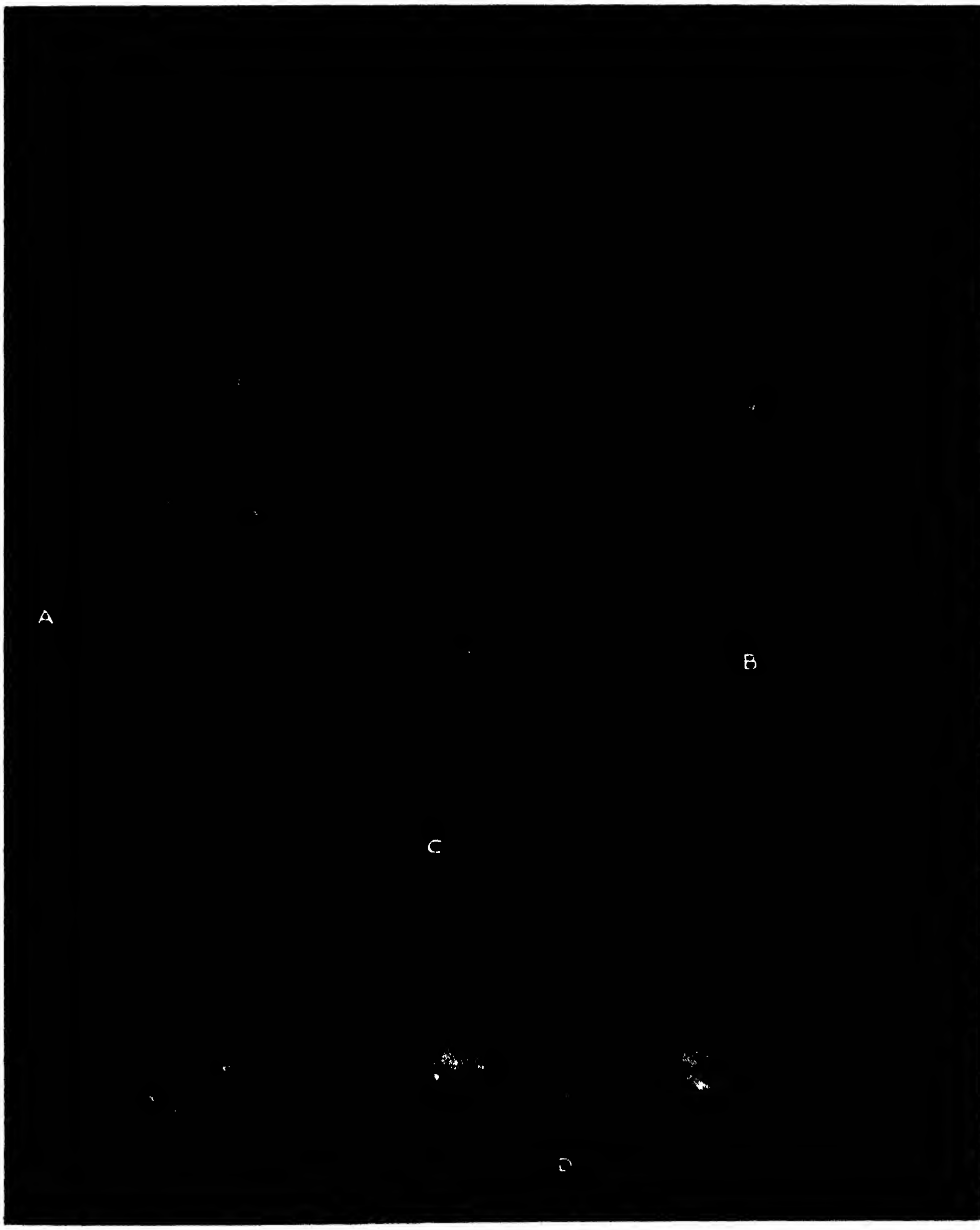


PLATE 5.—*Sternotherus odoratus: A,* Adult female, ventral view. *B,* Dorsal view of the same individual. *C,* Young specimen, three and a quarter inches long, dorsal view. *D,* Adult, lateral view.

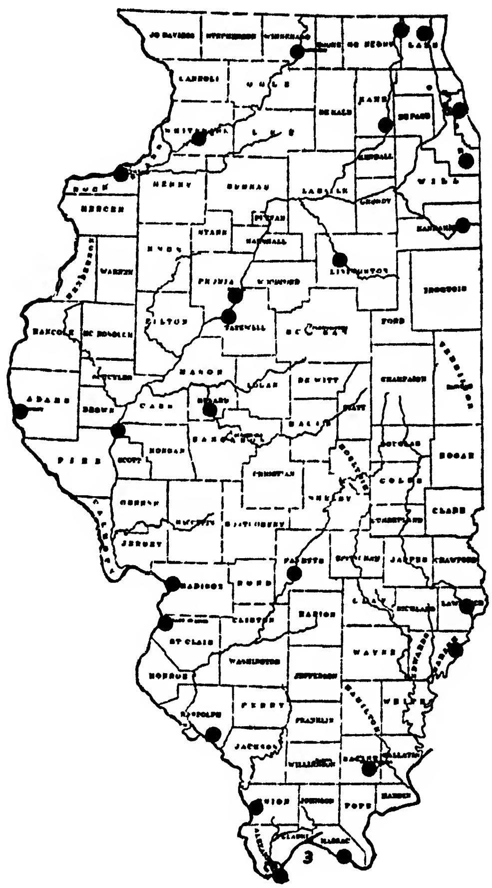
surface of each marginal scute. In young 42 mm long the mid-dorsal vertebral keel is still very prominent and highly notched, but the costal keels are reduced to a terminal nob at the posterior margin of each scute. Both carapace and plastron are now a lighter brown and the plastron shows a greater amount of yellow mottling. The stripes on the head are usually very conspicuous at this stage of growth.

SEX DIFFERENTIATION.—The tail is much longer and stouter in the male than in the female, and usually bears a blunt terminal nail. The dorsal surface of the tail in the male is smooth, while there is a mid-dorsal row of tubercles down the tail of the female. The plastral scutes of the males are smaller than those of the females of the same size, the areas between the scutes in the males being in consequence larger (see Text-fig. 10). The male exhibits two oval patches of scales on the inner surface of the hind limbs, one above and one below the knee, these areas being absent in the female. In cross-section, the plastron of the male is concave, that of the female flat or slightly convex.

GEOGRAPHICAL DISTRIBUTION.—*Sternotherus odoratus* is a species which has a very wide distribution over the United States. Its range extends over the entire eastern portion of the country to Maine and Massachusetts; westward it extends to western Missouri and Texas. The northern limit is southern Canada, from which it extends southward to and including Florida. Over the greater part of this vast range the species is common, becoming distinctly less abundant in Missouri and northeastern Texas.

ILLINOIS RECORDS.—This species is reported by H. Garman (1892) from Deep Lake in Lake County; Chicago; Peoria; Little Fox River at Phillipstown; and from Running Lake in Union County. Hurter (1911) records it from Madison and St. Clair counties on the Mississippi River; Weed (1923) from Meredosia on the Illinois River; Hay (1893) from Mt. Carmel on the Wabash. Blanchard (1924) reports it from Carrier Mills in Saline County, and Yarrow (1882) records a specimen (#14) in the U. S. National Museum from Chicago. In the Field Museum in Chicago are specimens from Momence (#323), Havana (#1754), and Homewood (#4092). The writer has examined many dozens of specimens from the following localities: Meredosia, Havana, Peoria, Rockford, Rock Island, Prophetstown, Aurora, Pontiac, Petersburg, Vandalia, Metropolis, Cairo, Mt. Carmel, Chester, Lawrenceville, and Quincy. In so far as the distribution within the state is concerned, the species is decidedly more abundant in the southern half than in the northern, and more common toward the east than toward the west. In terms of the number of individuals per given area it is more abundant in the Illinois River than in any other large stream within the state.

HABITAT.—This little species is highly aquatic in its habits, showing a marked preference for the smaller lakes and streams. The ideal habitat is a small, slow-moving, muddy-bottomed stream having an abundance of aquatic vegetation, or a semi-stagnant slough. They tend to avoid clear-water lakes, as well as all gravel or rock-bottomed waters. Small vegetation-choked lakes are an ideal environment, and in such localities they pick the deeper portions, seldom coming to land. So far as streams are concerned, the species tends to avoid the larger rivers, as is well illustrated by the situation at Meredosia on the Illinois River. While *Sternotherus odoratus* is found in the main channel of the river to some extent, the numbers in such a locality are as nothing when compared to the abundance of the species in Meredosia Bay.



MAP 3.—*Sternotherus odoratus.*

HABITS.—Probably the most aquatic of our local turtles, not excepting the soft-shells (Amyda) or the snapper (Chelydra). So aquatic is the musk turtle that it seldom comes to dry land, being content to wander about amid the bottom mud and vegetation of the lakes and streams. This tendency accounts for the overlooking of the species by observers in many localities where it is really common, for, unless one goes out looking for it, one is likely never to suspect its presence. For eleven summers the writer collected in the clear-water lakes of southeastern Wisconsin without ever seeing a musk turtle. Early one June morning he found one crossing the road coming from a swamp area. Later in the day he seined a pond in the middle of the swamp and captured 52 specimens in half an hour. The puddle was alive with them, their pointed snouts poking through the vegetation-covered surface, yet all but invisible amid the tangle of reeds and rushes. On a half-submerged log eight specimens were basking in the sun, only to disappear into the water at the first hint of danger. Where the species is found it is likely to be abundant, but

since it shows such a definite environment preference, it is likely to be of very local distribution.

The musk turtle is well adapted to its aquatic habitat. The feet are large, the toes well webbed. It can swim rapidly and strongly when necessary, but it prefers to wander aimlessly about on the bottom, poking about among the plant stems and bottom débris in search of food. It walks slowly along on the bottom, moving its head from side to side to peer under a dead leaf or to push half its body into the soft mud under a piece of rotten wood. The very long neck is highly mobile and the strong jaws snap voraciously and retain whatever food they find. When not wandering, the musk turtle may remain for hours at a time entirely motionless under a log, the head partially retracted. At such times the "moss" covered shell blends admirably with the bottom vegetation and affords the turtle what little protection it needs in its naturally somewhat opaque and dark surroundings.

Its highly aquatic adaptation has been shown by Ditmars (1908) who kept the musk turtle in a deep aquarium for several weeks. Here the turtles swam and crawled about in entire comfort, paddling to the surface occasionally for air, yet having no out-of-water footing. Under similar conditions almost every other species (except probably *Chelydra serpentina*) will die of exhaustion in a few days. The writer carried this experiment further, and kept *Sternotherus odoratus* under similar conditions for eighteen weeks without harm to the turtles.

The musk turtle is very timid by nature. The least disturbance sends it scurrying off its basking log, to which it will not return for hours after the danger is past, and then only after a prolonged, careful scrutiny of the situation from its nearly submerged position. When disturbed while on land, the head is retracted quickly, the legs drawn in, and the tail curled tightly under the shell. Thus it remains motionless for a long time. Eventually the head begins slowly to protrude, so slowly that its movement is barely perceptible. Then, after watching carefully for the least inkling of danger, the legs and tail are brought forth and the turtle resumes its journey. The manner of withdrawing within the shell is peculiar and is described by Agassiz (1857) as follows:

> The forelegs are carried round before the body; the elbow, somewhat raised, is carried directly back by the side of the head and neck into the scapular arch, the skin at the same time rolling off toward the feet and shoulders and leaving its muscles as naked as those of the neck and scapular arch about it; the forearm is turned back, but not quite on to the humerus; the hand is either laid in against the head and neck, or turned back on to the humerus. . . . The hind legs are withdrawn nearly horizontally, the knees like the elbows, though in a less degree, stripped of the skin; the foreleg is turned back upon the femur, and the foot again turned forward upon the foreleg. The tail is turned to one side. The head is drawn back to within the scapular arch, the skin rolling off from the neck, but not folding together before the head, as in the Emydoidae.

If annoyed or molested to a point where its slow anger is aroused, the turtle snaps viciously at any object within reach. The jaws are opened wide while the head is still completely withdrawn; then the head and long neck are slowly projected and moved toward the offending object. A sudden snap over a short distance, and the jaws close upon whatever disturbing element is within their reach. If they close upon the object of their wrath, the turtle attempts to retract the head again under the shelter of the carapace, still holding to the captured object.

When handled, or when its anger is awakened, the turtle emits a strong fetid or musky odor, which is responsible for the common name of "musk" turtle. This is due to a secretion emitted by a pair of well-developed glands which underlie the anterior lateral angles of the carapace. The material secreted is highly volatile, and the odor characteristic of the kinosternid group permeates the atmosphere for a distance of some feet. *Sternotherus odoratus* probably has these glands developed to a greater extent than any other member of the family; certainly the odor emitted is stronger than in any other species.

The males bear "stridulating organs" on the hind leg, as has been mentioned. By rubbing these patches of horny tubercles together, they are reported to make "stridulating sounds," but the present writer has not observed this performance. Whether this is associated with the mating phenomena is not known.

Nesting Habits.—There are but a few descriptions available of the nesting habits of this turtle, and these vary considerably. The summer work of Mr. Combs at Meredosia yielded no data on this subject, but the writer has twice seen the nest-digging in southeastern Wisconsin. In one instance the nest was in the sand about 150 feet from the pond in which the turtle lived. At 6:20 on the evening of June 22, the female came slowly out of the water and paused for about ten minutes at the water's edge while she looked about with her head raised to the fullest extent. Satisfied that all was well she headed off through the tall reeds straight for the patch of sand; there was no uncertainty in movements. Arriving here she paused again for a few minutes, her head again erect. Then she walked deliberately out to nearly the middle of the open area and began to dig. The process was slow and leisurely, the dirt being scraped away with alternating strokes of the hind feet, and piled up into two small heaps on each side of the hole. When the depth of the hole was about equal to the length of the carapace, she deposited her eggs therein, after which she filled in the hole again with her hind feet and headed straight back to the water. The time required for the digging, laying, and covering was forty-seven minutes, during which time she paid no attention to anything around her. When I dug the nest out I found it to be semicircular in shape, the roof arched to conform to the curva-

ture of the carapace. The hole descended at an angle of 50° to a depth of four and a half inches, and contained three eggs. The second case was similar in all particulars save only that this time the nest was dug in the grass of a lawn a hundred feet from the water and fifty feet above it on a hilltop. Here the ground was much harder; the nest was but two and three quarters inches deep, yet required nearly an hour for excavation. A distinct variation in nesting habits is reported by Eigenmann (1896) for the Turkey Lake country of Indiana: "The eggs are laid in the rotten wood in the tops of stumps standing in the margin of the lake. The turtles were frequently found in the tops of these stumps, and some of their eggs wedged as far into the rotten wood as the finger could bore. Rotten logs removed some distance from the water are also favorable places for egg-laying, and in a mucky place of small area at the edge of the lake 362 eggs were taken at one time. While passing along a wheat field some turtles were seen coming from it, and on inspection it was found that they had deposited their eggs in the ground in depressions made by a cow while walking over the ground when it was soft. Still other eggs were found in bundles of rushes drifted together." That this stump-utilization habit is unusual is indicated by Eigenmann's further statement: "The present large number [of stumps] is due to the rising of the lake after the building of the dam and the subsequent cutting down of the trees whose boles had become submerged. The habit of laying eggs in stumps cannot be much more than fifty years' duration." Quite frequently the writer has found stray eggs lying about in swamps, indicating that the female had passed an egg without any attempt at nest-building at all. Such eggs never hatch.

From circumstantial evidence at hand it would seem that the musk turtle lays either early in the evening, at night, or very early in the morning. Agassiz reports seeing it laying at half-past eight in the evening. The normal laying season in Illinois seems to be late in June. In southeastern Wisconsin I once found the nest of *Sternotherus odoratus* containing two eggs with very young living embryos within, on September 22. Whether this is a freak, or whether there may perhaps be a second laying season under particularly favorable climatic conditions, is not known. Neither is it known whether these young turtles would have hatched that fall or have "wintered" within the egg. Agassiz reports *Cinosternum pensylvanicum* (= *K. subrubrum*) laying one egg on October 7 which was, however, apparently unfertilized.

Eggs.—The normal egg complement is three, though occasionally four or five eggs are encountered. Babcock (1919) reports as many as seven in a clutch. The eggs are of an elongated elliptical shape, the ends equally rounded, and are covered with a hard, smooth shell of very fine

texture. This shell is exceedingly brittle. The average of 112 eggs measured by the writer shows their size to be 27.6 mm in length by 14.8 mm in width. Of the period of incubation nothing is known. The chief enemies of the eggs of this turtle are the skunk and the raccoon. Both of these animals have a decided fancy for turtle eggs, and the writer has found dozens of nests which have been dug out by them, the discarded eggshells lying about the excavation.

FOOD HABITS.—*Sternotherus odoratus* is primarily a carnivorous species, feeding principally upon aquatic insects, tadpoles, worms, mollusks, crayfish, and occasionally upon small fish. Insects such as grasshoppers and beetles are often found in the stomach contents, these probably being individuals that fell into the water and were snatched from the surface film by the ever-watchful turtle. Snails and clams, always species of small size, are often eaten. The species of fish which have been taken by the writer from the stomachs examined have always been "minnows": *Umbra limi, Notropis whipplii spilopterus, Poecilichthys* sp., *Notemigonus crysoleucas auratus.* Fishermen who practice their art in the shallow, weedy lakes, often catch these turtles on their hooks, particularly if still-fishing with live worms or grubs.

ECONOMIC IMPORTANCE.—This species, the smallest of our native Illinois forms, has practically no economic status one way or the other. Their flesh is never eaten because of the musky flavor, and they have but little tendency toward the habits of a scavenger. The fish they eat are of no consequence to anyone. They have been reported to eat fish eggs, but this certainly is a minor item in their diet and of no importance.

TABLE 4.—MEASUREMENTS OF ILLINOIS SPECIMENS OF *Sternotherus odoratus*,
(Measurements in millimeters; weight in grams)

Specimen No.	Carapace		Plastron			Head	Tail	Weight	Sex
	Length	Width	Length	Width	Depth				
1	123	83	94	56	51	28	41	...	♂
2	119	80	94	56	50	26	30	253	♀
3	124	82	87	52	42	25	40	233	♂
4	109	77	79	53	39	24	36	176	♂
5	101	70	75	49	36	23	35	134	♂
6	93	69	74	55	36	20	30	124	♂
7	90	65	72	50	35	19	26	119	♂
8	89	66	69	50	34	17	25	109	♀
9	112	75	86	56	41	25	28	185	♀
10	128	81	90	58	44	27	48	238	♂
11	110	76	79	55	40	26	43	188	♀
12	104	73	80	54	41	22	..	170	♂
13	111	81	86	57	42	23	25	201	♂
14	82	64	65	46	35	15	23	98	♀

PARASITES.—The musk turtle is almost always the host to a large number of leeches. The commonest species found on them is *Placobdella parasitica,* which attaches itself in numbers to the soft parts, but which apparently does the turtle no harm. On one occasion, however, I found a turtle in which a leech of this species had worked itself into the eye socket and had caused blindness in the associated eye. Internally nematode parasites are usually very abundant from the posterior end of the stomach through the small intestine.

GENUS KINOSTERNON SPIX

Terrapene (part) Merrem 1820
Kinosternon Spix 1824; Bell 1825
Cinosternon Wagler 1830
Uronyx Rafinesque 1832
Monoclida Rafinesque 1832
Staurotypus (part) Duméril & Bibron 1835
Kinosternum LeConte 1854
Goniochelys Agassiz 1857
Cinosternum Agassiz 1857
Thyrosternum Agassiz 1857
Platythyra Agassiz 1857
Swanka Gray 1870

Plastron moderately wide, the posterior lobe about two-thirds the width of the aperture and approximately equal in length to the anterior lobe; emarginate posteriorly and with rounded lateral angles; each lobe movable on a transverse hinge and capable of partially closing the aperture. Wings of the abdominal scutes wide and bearing a posterior groove. Carapace somewhat depressed rather than domed; first vertebral scute widely triangulate, the anterior base being two-thirds to three-fourths the height of the scute.

Kinosternon flavescens (Agassiz)

Platythyra flavescens Agassiz 1857
Cinosternum flavescens Cope 1875
Kinosternum flavescens Cope 1892
Kinosternon flavescens Stone 1903

DESCRIPTION.—The largest species of the family Kinosternidae found in North America, the carapace measuring up to 146 mm in length. Shell broad, greatly depressed, flat, often even-dished along the mid-dorsal line of the carapace. Carapace: first vertebral scute triangular, the apex (anterior margin) equal in length to the sides; truncate at the posterior margin. Second, third, and fourth vertebral scutes roughly hexagonal, with the anterior margin greater than the posterior. Fifth vertebral truncately triangular. First, second, and third costal scutes very large; the fourth conspicuously smaller. Marginals 22 in number, plus the nuchal. Nuchal scute very small. Ninth and tenth marginals conspicuously large, triangular, the apexes contiguous and the two scutes of equal height. Caudal marginals relatively small. This condition of the three pairs of posterior marginals is to be found in no other kinosternid. Scutes mostly smooth, with a slight tendency toward rugosity in the posterior region. Plastron large, and similar in type to that found in

the *K. subrubrum* group. Gular large, unpaired, its length approximately equal to the interhumeral suture. Humerals roughly rectangular. Pectorals triangular, the interpectoral suture very short (cf. Boulenger 1889, p. 36). Abdominals nearly square, the wings grooved posteriorly. Femorals triangular, with a very short interfemoral suture, this suture approximately one-sevénth of the interanal suture. Anals triangular, with

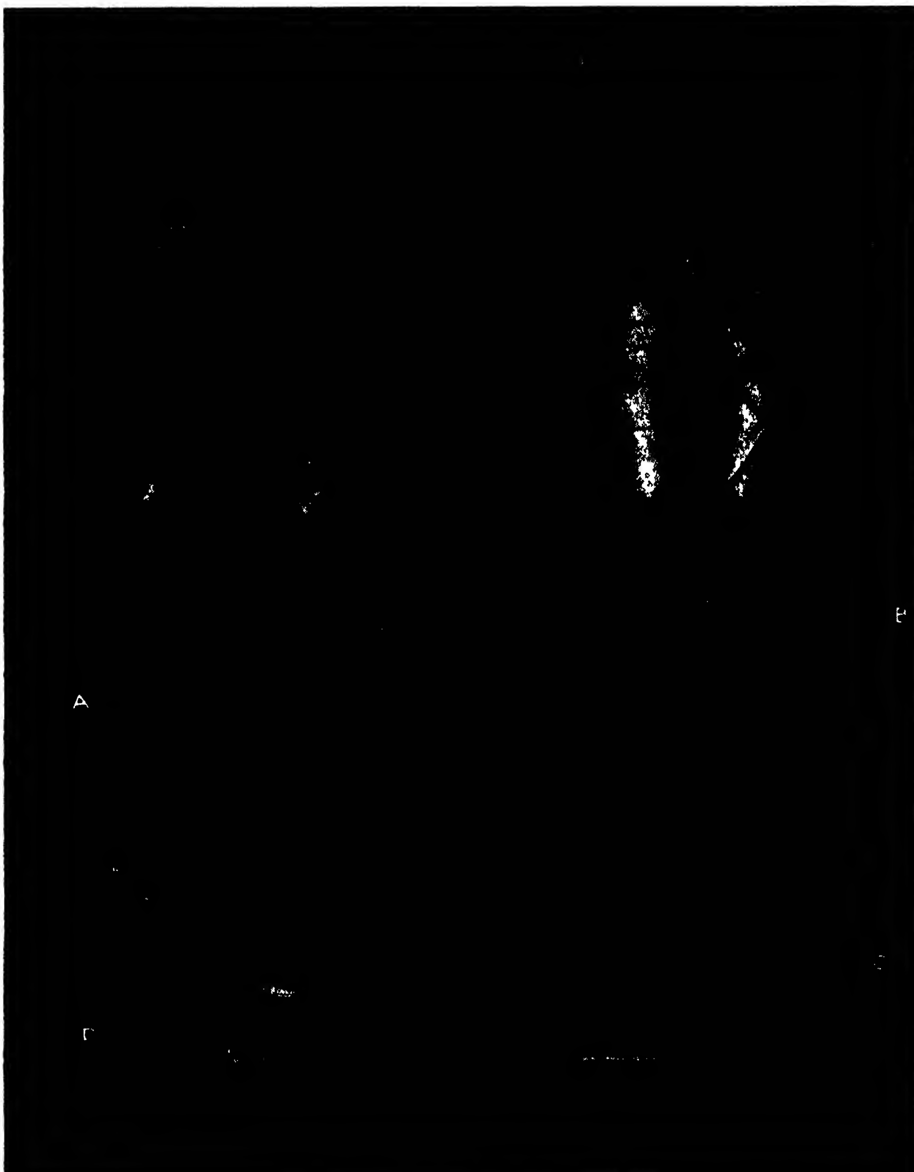


PLATE 6.—*Kinosternon flavescens: A,* Adult, ventral view. *B,* Same individual, dorsal view. *C,* Newly hatched young, dorsal view (Oklahoma specimen). *D,* Adult, lateral view.

a long interanal suture, and with a conspicuous round-shouldered notch posteriorly. Considerable cartilaginous material is found along the pectoral-abdominal and the interabdominal suture, and still more along the abdominal-femoral suture, the amount varying with the sex of the individual, being greater in males than in females. Axillary small; inguinal long and narrow, reaching to the seventh marginal. Head large and powerful. Top of head with a small bifurcated U-shaped nasal plate, the arms of the "U" following the dorsal rim of the orbit to its posterior margin. The shell of the upper jaw reaches the anterior ventral margin of the orbit, following half-way up it, but does not make contact with the nasal plate, leaving a fleshy bridge between the snout and the anterior dorsal margin of the orbit. Snout pointed. Upper jaw strongly hooked and with a prominent "first tooth." Posterior to this the profile of the jaw appears as a curved blade without any further prominent "teeth." Gular barbels prominent; second pair of barbels on the throat either inconspicuous, uni-lateral, or absent. Neck with but a few tubercles dorso-laterally and none ventrally. Horny scales on the wrist practically absent; inconspicuous. Claws on the fore limb strong, but highly graded as to length: the outer (fifth) is very small, the fourth twice its length, the third three times its length, the second four times its length, the first (inner) like the third. Posterior claws also graded, but to a much less extent. Tail long in the male, short in the female, but usually with a distinct terminal nail or "claw" in both sexes. Apparently this nail is in rare cases absent.

Coloration.—Carapace olive green, uniform in tone, the sutures being finely edged with black, which is increasingly inconspicuous in the older and larger specimens, yet wanting in newly hatched young. This black margin tends in some specimens to overlap the suture as in *K. subrubrum hippocrepis,* while in others it lies as the posterior boundary of the anterior scute, much as in *K. subrubrum subrubrum.* Plastron light in color, yellowish, with a tendency toward brown. Soft parts gray-green, darker above and lighter beneath; unmarked. Throat, sides of neck, and head yellow. Head without markings of any kind. Jaws horn colored, mottled with dark olive.

Young.—The young exhibit the general configuration and coloration of the adult, but are much more circular in form. The most conspicuous difference lies in the condition exhibited by the marginals in newly hatched and very young individuals. Whereas in the adult the ninth and tenth are conspicuously large and elevated, in very young individuals (32 mm) this is not the case, these two scutes being actually smaller and less elevated than the seventh and eighth. In young having a carapace 67 mm in length the conspicuousness of the ninth and tenth marginals is already well established and typical of the adult condition.

A further feature of the young lies in the fact that the costal and vertebral scutes bear what appears to be a broad band impressed along the

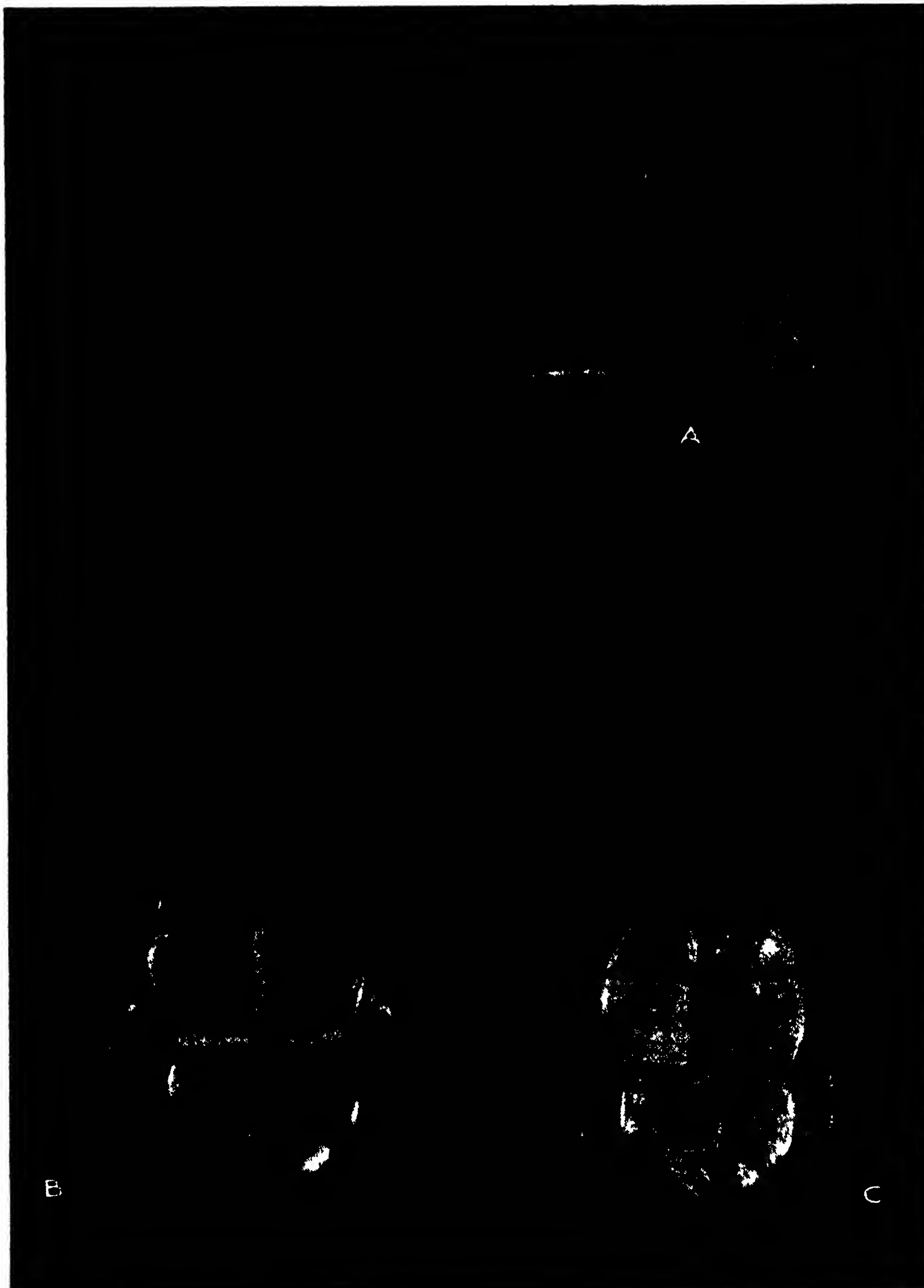


PLATE 7.—*Kinosternon flavescens: A,* Three-quarters posterior view of an adult, to show the relative size and shape of the last three marginal scutes. *B,* Adult male, ventral view. *C,* Adult female, ventral view.

anterior and lateral margins of the scutes, this band being separated from the rest of the scute by a tiny ridge, giving the scutes an appearance of being slightly rugous. (The above descriptions are taken from specimens #3642, 4617, and 9958, Museum of Zoology, University of Oklahoma, kindly loaned by Dr. A. I. Ortenburger).

Sex Differentiation.—The typical kinosternid features hold true in this species in so far as sexual dimorphism is concerned. In males, the tail is much longer than in females. The beak of the upper jaw is more pronounced in males than in females. The male has "stridulating organs" on the inner surface of the hind legs well developed in the form of a group of small, but strong, horny tubercles, which are absent in the females. Males are considerably larger than females.

Geographical Distribution.—*Kinosternon flavescens* is distinctly a western and southwestern species, the occurrence of which within the limits of Illinois is, to say the least, surprising. Stejneger and Barbour (1923) give its range as "Texas, north to Kansas and Colorado, west to Arizona." Yarrow (1882) reports it from Fort Yuma, California, Fort Union, New Mexico, and Utah; Boulenger (1889) from Arkansas, Western Texas, and the Gila River; Siebenrock (1907) from Arkansas, Texas, and Arizona. Ortenburger and Freeman (1930) report that "without question this is one of our commonest, if not *the* commonest turtle in Oklahoma wherever water is available."

Illinois Records.—Until the report by Cahn (1931) of the finding of this species in Illinois, it was unrecorded from the state. At the time of publication of that paper, five specimens only had been taken, all of these on the Illinois River at Meredosia Bay. These were taken by Dr. David H. Thompson of the Illinois State Natural History Survey, who reported that he had seen probably twenty to twenty-five additional specimens on the Illinois River between Meredosia and Peoria—a distance of approximately 90

Map 4.—*Kinosternon flavescens.*

miles by river. During the summer of 1931 Mr. Joe Combs, working and collecting for the writer at Meredosia Bay, was able to obtain an additional 11 specimens, comprising both sexes, so that the number now on hand from Illinois totals 16. One of these has been deposited in the United States National Museum, #83190.

HABITAT.—From all reports, *Kinosternon flavescens* is preëminently a pond turtle. In western Oklahoma, where it is one of the commonest of the turtles found, it inhabits roadside ditches and cattle ponds (often artificially constructed) of almost any size. So common is it in this western region that Ortenburger finds one or more per each hundred or two hundred feet of roadside ditch. They are highly aquatic, as is the case in other kinosternid species, and seem most at home in the muddy bottoms of shallow ponds, where they often lie partially buried in the soft material. The same applies to the species as found in Illinois. While the five original specimens were taken from hoop nets used by fishermen to catch catfish, ten of the remaining eleven specimens were all taken from a single small, muddy overflow pond which had but a few inches of water in it. This temporary pond was but a hundred feet from the river, yet had no connection with it. The turtles must therefore have chosen to inhabit it rather than the river, and they were found lying in the soft mud at the bottom, apparently quite content. The sixteenth specimen was found walking down a sandy path near the edge of the river.

Unfortunately, we can give almost no information concerning this interesting turtle. Of the habits, nest, eggs, and incubation periods nothing is known, so far as I have been able to ascertain. Agassiz (1857) figures the newly hatched young, but not the egg, and gives no information or discussion of the species. It was hoped that some light might be thrown on these obscure phases of its life history as a result of the work of the summer of 1931, but the field work yielded no results in this

TABLE 5.—MEASUREMENTS OF ILLINOIS SPECIMENS OF *Kinosternon flavescens*
(Measurements in millimeters; weight in grams)

Specimen No.	Carapace		Plastron			Head	Tail		Weight	Sex
	Length	Width	Length	Width	Depth		Total	A-T		
1	146	98	121	86	45	30	58	22	483	♂
2	138	98	114	79	43	30	57	20	422	♂
3	128	90	108	75	42	27	53	18	391	♂
4	140	99	121	83	45	30	54	18	446	♂
5	132	94	118	77	43	28	55	19	412	♂
6	105	78	93	60	41	23	51	16	253	♂
7	132	93	114	76	50	29	56	18	401	♂
8	137	97	112	84	51	30	55	19	457	♂
9	137	94	120	83	53	29	54	19	419	♂
10	135	94	104	75	49	31	53	17	412	♂
11	142	97	120	75	49	30	56	20	461	♂
12	142	97	120	73	48	31	54	20	450	♂
13	112	86	106	69	42	22	22	11	296	♀

direction. As a matter of fact it is interesting to note that of the 16 specimens taken to date, fifteen are males. Whether or not this preponderance of males is of any significance in relation to the habits of the species is not at present clear. The single female was taken on June 20 from the temporary pond previously mentioned. Dissection showed the ovary to be small, but it contained two ovarian eggs well along in their development and apparently to be laid in a month or so. The stomach contained a quantity of vegetable matter which apparently was either grass or some semi-aquatic plant having similarly slender leaves.

Just how we are to explain the appearance of this species in a thriving condition so far removed from its hitherto known range is something of a problem. That they are thriving is indicated by the fact that the bigger specimens taken are larger than any loaned me from the region of their greatest abundance. Probably no river in the United States has been more thoroughly "worked" by zoologists than has the Illinois, particularly at the very place from which these turtles came. The Illinois State Natural History Survey began its investigations here in the 1870's, and has continued almost without interruption to date. Garman, gathering material for the Survey, collected here, yet found no evidence of this species. It escaped the notice of the investigators who inspected hundreds of nets set by fishermen over a period of many years, and which caught thousands of turtles. True, these men were not interested in turtles, yet its peculiar form might well have attracted attention. Are we to conclude that it is a new arrival in the district, or that it is simply a rare species which has, somehow, been overlooked? Or are we to say that it is a "transplant" recently introduced or liberated in the vicinity? The latter view seems highly improbable in view of the numbers recorded and the abundance of the species once its optimum environment is located, not to mention the distribution over 90 miles of the river. The condition of the female indicates that the species is breeding, hence established. About all that can be said is that the turtle is rare, that its distribution in the state is limited according to our present knowledge to the middle reaches of the Illinois River, and that it is an established species.

Kinosternon subrubrum subrubrum (Lacépède)

Testudo subrubra Lacépède 1788
Testudo pensylvanica Gmelin 1788
Emys pensylvanica Schweigger 1814
Terrapene pensylvanica Merrem 1820
Cistudo pensylvanica Say 1825
Kinosternon pensylvanicum Bell 1825
Kinosternon oblongum Gray 1844
Kinosternon doubledayi Gray 1872
Kinosternon punctatum Gray 1870
Thyrosternum pensylvanicum Agassiz 1857
Swanka fasciata Gray 1872
Cinosternum pensylvanicum Boulenger 1917
Kinosternon subrubrum subrubrum Stejneger & Barbour 1917

Description.—Carapace rather elongate and narrow; smooth, unkeeled. The curvature of the shell is gradual at the anterior end, appearing to be somewhat depressed, and abrupt posteriorly beginning with the fourth vertebral scute; the fifth vertebral is nearly vertical. The anterior margin of the carapace is almost truncate, the posterior oval in outline. Costal scutes very large, transverse in their major axis. Vertebral scutes relatively small; marginals very small and elongate. The first vertebral

Plate 8.—*Kinosternon subrubrum subrubrum: A,* Adult, ventral view. *B,* Dorsal view of the same individual. *C,* Three-quarters posterior view, to show the relative size and shape of the last three marginal scutes. *D,* Adult, lateral view.

scute is triangular, truncate at its apex, which is directed posteriorly; the second, third, and fourth are roughly hexagonal; the fifth pentagonal. Costal scutes in a graded series, the first being the largest. The gular is very small, wider in front than behind, and larger in its ventral aspect than in its dorsal. Marginals entire, though occasionally showing a slightly sinuate condition, but never flaring. The tenth marginal is much enlarged, encroaching into the posterior margin of the fourth costal scute. The plastron is acutely rounded in its anterior border and shallowly notched posteriorly; both anterior and posterior lobes are movable. Gular scute single, triangular, and less than half the length of the anterior plastral lobe. Humeral scutes with their median suture are very short, so that the humerals almost meet the abdominals; the pectorals are not involved in the bridge. Abdominals almost square, their wings forming the major part of the bridge. These wings bear a posterior groove and exhibit a prominent anterior shoulder. Femorals triangular, the apex posterior-lateral, and with a very short interfemoral suture. The anals are tringular, with the apex directed anteriorly. Axillary very small, elongate; inguinal large. The axillary and inguinal scutes meet between the wings of the abdominals and the marginals, to help complete the bridge. In some specimens the plastral scutes are rough and exhibit a series of concentric striae; in others these striae are worn down, leaving the plastron smooth. Head large, the snout somewhat attenuated; jaws strong, the upper hooked. A pair of barbels under the chin, and a second pair farther back on the throat. Eyes located well forward. Limbs short but strong, the anterior with several transverse scales on the dorsal surface, and a few small scales on the palm. Posterior limbs without the dorsal scales, but exhibiting the palmar series. Digits 5-4; claws short, stout, curved. Tail short. Skin finely tuberculate.

Coloration.—The carapace is uniformly olive brown, each scute with a narrow black margin along the suture. This black band is confined to the scute anterior to the suture, not overlapping the suture as in the case of *Kinosternon subrubrum hippocrepis*. The plastron varies from brown to yellow or horn-color, the brown apparently wearing off with age, but persisting along the sutures. The head is olive brown, with distinct yellow mottlings in the form or irregular lines and amoeboid spots. Under side of the head yellow with olive-brown reticulations and spots, becoming indistinct on the neck. Remaining soft parts grayish brown. Iris chestnut brown.

Young.—The young conform to the general plan of the adult, except that the carapace often exhibits a trace of three small keels, one row on the vertebral scutes and one row on each of the costal series.

Sex Differentiation.—The males bear a small patch of horny, keeled tubercles on the posterior side of the leg, and another similar

patch below the thigh. The male has the tail terminating in a horny, nail-like claw.

Geographical Distribution.—The range of *Kinosternon subrubrum subrubrum* can at present be given best only in general terms, and may be said to include the eastern portion of the United States from New York, where it is very rare, westward to Illinois. Hay (1892) reports it from Knox county (southwestern) and from Terre Haute (westcentral) Indiana under the name of *K. pensylvanicum.* It extends from these more northern states southward to include Tennessee (Blanchard 1922) and Louisiana (Viosca 1931), but seems not to reach peninsular Florida. Under the older name of *Kinosternon pensylvanicum* (and the various spellings of both generic and specific names) is included both *subrubrum subrubrum* and *subrubrum hippocrepis,* and since the earlier investigators failed to recognize the two closely related forms and did not differentiate between them, it is very difficult at the present time to delimit exactly either form because of this inclusion.

Illinois Records.—Under the name of *Cinosternum pensylvanicum,* this form is included in the herpetology of Illinois by Garman (1892). At least it is presumed by the writer that the form to which Garman has reference is *K. subrubrum subrubrum,* for the Garman collection of turtles has completely disappeared, and it is impossible now to check on his specimens. This must not be construed as a reflection upon the excellent work of Garman, but without the original material for study and verification, it is difficult to do more than interpret his designation. As to the occurrence of *subrubrum* in Illinois, Garman says: "Southern Illinois, not rare; Peoria (Brendel); Mt. Carmel, common (Ridgway)." The only specimen which the present writer has from Illinois is a very typical shell found near Cairo in 1930. The turtle was found dead in a swamp north of Cairo, in a locality to which it could not possibly have been washed by floods of the Mississippi River.

Map 5.—*Kinosternon subrubrum subrubrum.*

HABITAT.—The discussion which follows is based of necessity upon our knowledge of the species as found in localities other than Illinois. *K. subrubrum subrubrum* is found in ponds, muddy ditches, and weedy lakes. Its general environmental preferences are rather similar to those of *Sternotherus odoratus,* although it is considerably less aquatic than that species. It is normally absent from streams with gravel bottom and current, preferring the mud in which it can bury itself for protection, and the quiet waters more often associated with mud conditions. It is not adverse to journeys upon land, and may be found quite a distance from its usual abode during the summer. In this respect it differs markedly from *S. odoratus.*

HABITS.—Unlike the other Illinois species of the family, this form exhibits a tendency to appear frequently on the dry land, wandering away from the water for considerable distances. Whereas the other species hibernate in the mud at the bottom of the ponds, *K. subrubrum subrubrum* has often been found buried six to twelve inches down in the dry soil quite removed from the proximity of water. Other burrows, apparently in dry soil, are found to terminate in a small chamber close to the ground-water level, in which the bottom at least is wet and muddy. When the turtles emerge from their burrows after hibernation, they are very sluggish, rather emaciated, and heavily caked with dried mud.

This turtle, however, spends most of its time in water, where it wanders about in search of food much as does *S. odoratus.* It is a strong swimmer, capable of making rapid progress with this method of locomotion. To quote Agassiz (1857): "The slender legs are fitted for traveling on dry land, but easily carry the body through the water over its bottom. When surprised away from the water, the animal seeks the nearest hiding-place; if danger is close at hand, it quickly withdraws the exposed parts into the shield, and, if pressed still farther, it resorts at last to biting, not throwing the head quickly and forcibly out as the Chelydoidae do, but stretching it out rather slowly toward the assailant, and then snapping the jaws forcibly upon it." Although this quotation is applied by Agassiz to kinosternid turtles in general, it fits admirably the observed behavior of the present species. While not as vicious as *Sternotherus odoratus,* this species is capable of biting when occasion seems to demand, preferring, however to retreat within its shell. After the head is withdrawn, *K. subrubrum subrubrum* has a greater degree of protection, due to the larger size of the plastral element, and to the fact that the plastral lobes more completely close the ventral aperture.

When disturbed, this musk turtle emits the same type of musky odor which is characteristic of the family, though to a much less degree than in *S. odoratus.* In fact, the writer has found the odor emitted by

specimens in the laboratory to be very weak and not at all disagreeable. It is doubtful whether this excretion is of any protective value.

NESTING HABITS.—The writer has never seen the nest of this species, and there is little information in the literature describing the nesting habits. Presumably they are not very different from those of *Sternotherus odoratus*. Brimley (1903) reports that the eggs are sometimes found in holes in the banks of streams, and that they are frequently plowed up in low ground.

EGGS.—The eggs of this species resemble those of *S. odoratus* so closely as to be almost indistinguishable from them, though they are a trifle smaller in size. They are an elongated oval in shape, with blunt ends, and are covered with a shell of remarkable thickness for so small an egg. This shell is of very fine texture, perfectly smooth, due to a slight glaze, and exceedingly brittle. The eggs number from two to five in a clutch, three being the usual number deposited by one female. The average size of 7 eggs measured by the writer shows them to be 27.4 mm by 14.3 mm. Nothing is known of the period of incubation.

FOOD HABITS.—This is largely a carnivorous species, which is reported to feed upon fish and insects. A specimen shipped to me from Louisiana had the remains of earthworms and five beetle wing coverts in the stomach. Kept in the laboratory, they seem entirely satisfied with a diet of chopped meat. In nature, they are reported to nibble daintily at the baited hooks dangled by fishermen for more valued prizes.

ECONOMIC IMPORTANCE.—The small size and the musky flavor of this little turtle makes it unfitted for human consumption. It is very doubtful whether the food habits of the species render it either an economic asset or liability.

PARASITES.—When compared with specimens of *S. odoratus,* this species is much less parasitized by leeches, due probably to its more frequent journeys to land. The alimentary canal is far freer of internal parasites; though the writer has taken nematodes on several occasions from the pyloric end of the stomach.

FAMILY TESTUDINIDAE

Testudinidae, Emydidae (part) Gray 1825; Bell 1828; Ritgen 1828
Tylopodes, Steganopodes (part) Wagler 1830
Testudinidae, Emydae (part) Gray 1831
Chersites, Elodites Cryptoderes (part) Duméril & Bibron 1835
Emydoidae, Nectemydoidae, Deirochelyoidae, Evemydoidae, Clemmydoidae, Cistudinina, Testudinina Agassiz 1857
Chersemydina (part) Strauch 1862
Testudinidae, Cistudinidae, Emydidae, Malaclemmydae, Pseudemydae, Bataguridae Gray 1870
Testudinidae, Emydidae (part) Cistudinidae Cope 1882

Chersemyda (part) Strauch 1890
Cryptoderinea (part) Vaillant 1894
Emydinae Siebenrock 1909

External Diagnosis.—Turtles having a bony shell, covered with epidermal scutes, which is moderately (never greatly) depressed, or (extralimital) highly arched. Carapace oval, broadest posteriorly, and highest at about the middle, from which the shell slopes in all directions to flaring marginals. Scutes of carapace: 5 vertebrals, 8 costals, 25 marginals. Plastron with 12 (rarely 11) scutes; axillary and inguinal elements usually present. Anterior lobe of plastron (and rarely also the posterior lobe) in some species movable on a transverse hinge capable of closing the aperture. Toes broadly webbed in aquatic species and imperfectly webbed in terrestrial forms. Head of moderate size, covered with smooth skin, and retractile within the shell. Jaws naked. Digits moderate to short and with either 4 or 5 (extralimital exceptions) claws. Tail short.

Osteological Diagnosis.—Nuchal plate without costiform processes. Plastron composed of 9 dermal elements, the entoplastron present. Caudal vertebrae procoelous. Temporal arch usually present; no parieto-squamosal arch. Phalanges with condyles. Neck completely retractile.

Genus Clemmys Ritgen

Emys (part) Duméril 1806
Chersine (part) Merrem 1820
Clemmys Ritgen 1828
Clemmys (part) Wagler 1830
Terrapene (part) Bonaparte 1830
Chelopus Rafinesque 1832; Cope (part) 1865
Geoclemys (part) Gray 1855
Nanemys Agassiz 1857
Calemys Agassiz 1857
Glyptemys Agassiz 1857
Actinemys Agassiz 1857
Mauremys Gray 1869
Sacalia Gray 1869
Emmenia Gray 1869
Eryma Gray 1869

Shell moderately depressed. Axillary and inguinal elements well developed, reaching exactly to the first and fifth costal scutes; bridge wide. Alveolar surfaces of the jaws narrow and without a sharp medial ridge. Endoplastron with a suture between the humeral and pectoral bones. Choanae located between the eyes; skull without a dorsal medial ridge, and with a bony temporal arch present. Neck fairly long. Tail stout in the adult. Digits fairly well webbed.

Clemmys guttata (Schneider)

(Spotted turtle; speckled turtle)

Testudo guttata Schneider 1792
Testudo punctata Schoepff 1792
Emys guttata Schweigger 1814
Emys punctata Merrem 1820
Terrapene punctata Bonaparte 1830
Nanemys guttata Agassiz 1857
Clemmys guttata Strauch 1862
Geoclemmys sebae Gray 1869
Geoclemys guttata Gray 1870
Chelopus guttatus Cope 1875

Description.—Shell oval, somewhat depressed. It is wider posteriorly and without a trace of a vertebral keel in the adult. First vertebral scute pentagonal, shield-shaped, the remaining vertebrals hexagonal. The second vertebral with the anterior border shorter than the posterior; third vertebral with the anterior and posterior margins approximately

Plate 9.—*Clemmys guttata: A,* Adult, ventral view. *B,* Adult, dorsal view. *C,* Adult, lateral view. *D,* Head study of an adult. *E,* Newly hatched young, ventral view. *F,* Same individual, dorsal view.

equal in length. The fourth vertebral has its posterior margin only a trifle over one-half the length of the anterior border. In the costal series the first scute is the largest, but the second the widest; the first tends toward the triangular, though it is a trapezium, while the remaining are rectangular, the posterior scute tending toward square. The fourth costal is the smallest of the series. Nuchal long and exceedingly slender. Outer border of the marginals entire, not emarginate or serrate, though there is a shallow notch between the caudal marginals. There is a tendency toward sculpturing or rugosity on the scutes of the carapace. Plastron large, filling most of the aperture, the posterior lobe more than three-quarters the width of the carapace. The anterior lobe is truncate and without a movable hinge. Gulars sharply triangular. Humerals triangular, the interhumeral suture being very short, so that the posterior angles of the gulars almost touch the pectorals. Pectoral scutes rectangular. The abdominals are the largest of the plastral elements and, while rectangular are approaching the square. Femorals approaching triangular, the interfemoral suture being short and from two to three times the length of the interhumeral suture. Anal scutes large, the interanal suture usually a trifle longer than the interabdominal suture; a shallow notch exists between the posterior margin of the anals. Gulars usually with fine longitudinal striations. The remaining plastral elements tend to have concentric striations which are markedly angular in character centering about the posterior lateral angle of each scute; in old specimens, however, these striations are likely to be worn away. The bridge is rather narrow, approximately one-half the width of the posterior lobe, and involves the full width of the abdominals and the posterior half of the pectorals. Axillaries and inguinals absent, or very small and rudimentary. Head moderate to small, covered with a tightly drawn and perfectly smooth skin. Snout blunt, the upper jaw with a deep median notch and with the alveolar surface very narrow. Lower jaw with a wide sheath externally, and with a sharp, upward hook. Skin of the neck finely granular. Legs and feet covered with scales, those on the anterior face of the limbs large and overlapping. Feet rather small, imperfectly webbed, the toes with short claws. All 5 of the digits of the fore limb with claws; hind limb with only 3 digits bearing claws. Tail short.

Coloration.—Carapace uniformly black, with an occasional tendency toward rust. Each scute bears from one to ten or more round, bright orange-yellow spots. The tendency is for each of the marginals to bear a single round spot, but often more than one is present on the scute. The plastron is mostly black, and is blotched with orange. Head and neck black, dotted dorsally with orange, and with a large orange blotch just above the ear; ventral surface mottled with orange and with a tendency toward a lateral stripe extending backward from the angle of the jaw

(see discussion of color *in re* sex differentiation). Limbs black above, with orange dots, the orange predominating ventrally. Tail black, with a few small orange dots dorsally, blending into orange around the anus.

YOUNG.—The very young exhibit a trace of a vertebral keel, which entirely disappears with age. Each scute of the vertebral and costal series bears but a single yellow to orange spot, while on many of the marginals the dorsal spot is absent. With increasing age, other spots appear on the carapace as well as upon those marginals which originally did not possess a spot.

SEX DIFFERENTIATION.—In the male, the plastron is somewhat dished or concave in the central area, while in the female this concavity is absent. While the tail is about the same length in both sexes, the anus of the male is placed in a position to bring it *beyond* the edge of the carapace, while in the female it is under the carapace. Yerkes (1905) has pointed out that, although the females are slightly smaller than are the males, they bear about 15 per cent more spots on the scutes of the carapace, the average number for males being 60, for females 69. The concavity of the plastron of the male and the position of the anus are listed by Blake (1921), who also gives the following sex distinguishing features: (1) The horny part (sheath) of the jaw of the male is dusky, of the female pale yellow. (2) The female has a conspicuous yellow or orange mandibular stripe reaching half the length of the neck, while the male has but a few spots or at most a very weak streak here. (3) The throat of the male is black, with few yellow specks, while the female has the throat heavily streaked and spotted with yellow. (4) The female has a well developed supra-auricular yellow line, or a series of yellow spots, while in the male this line is poorly developed. (5) In the female there are a few yellow spots on the crown in front of the eyes, while in the male there are but one or two such spots.

GEOGRAPHICAL DISTRIBUTION.—The spotted turtle, *Clemmys guttata,* is an eastern species, the western limit of whose range lies in Wisconsin and Illinois. It is common throughout the Atlantic States from Maine to northern Florida. It is less common in the northern reaches of its range in the New England states, but is a common species in the southern members of this group. Morse (1904) reports that, while not rare in Ohio, it is found over most of the state, but is not a common turtle; Ruthven *et al* (1912) report it from most of the counties composing the southern third of Michigan. In Indiana, Hay (1892) reports it from a number of localities in the northern part of that state, including Lake Maxinkuckee, and in his "Preliminary Catalogue" he reports it as being "rather common about La Porte and in the marshes of the Kankakee River." The westernmost records lie in southern Wisconsin. For this state Higley (1889) reports it from Walworth county, Beloit, Madison,

and Eau Claire; to these records Pope and Dickinson (1928) add specimens from Waukesha County and from Fond du Lac County, and Cahn (1929) adds a second record from Waukesha County.

ILLINOIS RECORDS.—*Clemmys guttata* has not previously been reported from Illinois, and no mention of it occurs in the literature of this state. The University of Illinois now has in its collection two specimens of the species collected by the writer in June, 1927, in a small pond just beyond the Illinois end of Wolf Lake, Cook County. So far as the writer knows, these constitute the only Illinois records.

HABITAT.—The spotted turtle is an aquatic species which, however, spends a considerable amount of its time on land, often quite away from the water. Its choice of habitat lies with swamps, small weedy ponds, and streams, and in the east even salt marshes. Above all else it prefers a swamp or a pond with a muddy bottom in which it can bury itself, and avoids streams with a marked current. As between lakes and streams, its preference is for lakes and shallow ponds. When the spirit moves—which may be at any time during the summer—the turtle undertakes overland journeys of considerable length, wandering about in sphagnum bogs or out into the open fields. These journeys are not necessarily associated with the nesting instinct or with the drying up of the ponds; they seem, rather, to be the gratification of a "wanderlust" which frequently attacks the turtles and drives them afield.

MAP 6.—*Clemmys guttata.*

HABITS.—These turtles exhibit a very marked difference in some of their habits when their behavior in water is compared with that on land. In the water they are exceedingly shy and wary. Sunning themselves on a protruding log out in the pond, or in the midst of a clump of half-submerged grass, the first sign or suspicion of danger sends them scooting off their perch into the protection of the mud and aquatic vegetation.

A desirable log may have turtles piled on top of it in two or three layers, the late arrivals climbing up on the backs of those already enjoying the sunshine. Experiments carried out by the writer years ago with this species in Massachusetts, showed that individuals have certain favorite perches and that they tend to return to the same sunning place day after day throughout the season, indicating at the same time that while in the water they are not given particularly to wandering far from their favorite spot. On land, however, the turtle is quite solitary in its habits, and seldom is more than a single individual found. The impulse which sets them wandering seems to destroy at the same time the gregarious instinct, and their rambles on shore are quite solitary. The timid disposition persists on land, and the turtle withdraws its head quickly when danger threatens and is very slow about resuming its progress when the crisis is over. Just why this species should be so shy is a problem, for it has almost no enemies outside of animals like skunks which dig up its eggs. Associated with this timidity there is no trace of aggressiveness or viciousness under any circumstances; no matter how much the turtle is teased or annoyed it never snaps. In captivity this timidness persists for a long time, but eventually at least partially wears off and the creature makes a very good aquarium or terrarium pet.

NESTING HABITS.—The spotted turtle lays its eggs between the middle of June and the first of July over most of its range. Copulation, according to Babcock (1919), occurs in the water. A true amplexus takes place, the male embracing the female so tightly that the pair can be raised out of water by lifting the male, which is on top. The female leaves the water in order to find the proper place for her nest, and often wanders quite a distance from the water's edge. The site selected may be either in sand or in dirt, but it is always in material of fine texture. The hole is dug with the hind legs entirely, and is a vertical pit from two to four inches deep, and without any notable terminal chamber. The time required is upward of half an hour, depending upon the type of material being excavated. Standing about vertical in the hole, with little more than the head and shoulders protruding, the turtle lays her complement of eggs. When oviposition is completed, the female crawls out of the hole, and fills up the cavity with the excavated dirt, using, again, only the hind legs. If the turtle is disturbed while digging the hole, she retreats within the shell and patiently waits until things quiet down; she seldom will withdraw from the site of operations or give up the hole she has begun. Agassiz (1857) states that the spotted turtle lays her eggs in the evening between four and eight-thirty. This unusual time of day for a turtle to lay—unusual because most other species lay earlier in the day—may well be the result of the timid disposition possessed by the species.

Eggs.—The eggs usually number either two or three, very rarely four. and in shape are an elongated ellipse with sharply curved ends. They are covered with a tough, white membranous shell. The size varies closely around 30 mm by 16 mm.

Incubation.—Babcock (1919) publishes some interesting data on the period of incubation. The eggs in question were laid on June 15, on which date they were buried in sand. They hatched on September 6, giving an incubation period of 82 days for this individual. However, nothing is said as to the conditions under which these eggs were kept—whether natural or artificial, whether indoors or out—so that there is no way of telling whether this is a normal incubation period for the species or whether the regular interval has been interfered with. Upon hatching, the young are possessed of an "egg tooth," a horny tubercle on the tip of the snout, which is the pick used by the baby in breaking the shell when it is ready to emerge. This tubercle disappears at the end of the first week, and the stump of the umbilical cord disappears at about the same time, though the umbilicus remains visible for a long time thereafter. The young are very active on hatching and are good climbers. The rate of growth of the carapace, as reported by Babcock, is as follows: at hatching, 26 mm; first month, 30 mm; second month, 32 mm; fifth month, 32 mm. On the tenth day the young were fed angle worms, but at the end of the second month they ceased eating and did not survive the winter. Perhaps the slow rate of growth following the first month after hatching (October to February), outside of the fact that the young refused to eat, is associated with the period of normal hibernation.

Food Habits.—*Clemmys guttata* is largely a carnivorous species, although vegetable matter figures in its diet to a small degree. Surface (1908), who has published the only comprehensive account of the food habits of turtles, says, in regard to twenty-seven specimens examined: "Only one-ninth of the individual specimens had eaten vegetable matter, and in fact there was very little plant tissue found in the stomachs, while all of them contained animal matter. Not only is it remarkable that all contained animal tissue, but also that all of them had eaten insects." A list of the animal forms found includes: worms, slugs, snails, small crustaceans, crayfish, millipedes, spiders, and insects representative of the Ephimerida, Plecoptera, Odonata, Hemiptera, Neuroptera, Lepidoptera, Coleoptera, Diptera, and Hymenoptera. Many of the insects eaten are not aquatic species, and these probably were picked up from the surface of the water rather than gathered during the terrestrial journeys. Like most aquatic turtles, the spotted turtle apparently eats and swallows only under water, and hence it appears doubtful that much material is consumed while on land. Hay reports it as eating tadpoles and small frogs. They also eat angleworms and soft-bodied forms of insect larvae.

ECONOMIC IMPORTANCE.—Probably none so far as man is concerned. The insects eaten represent few that are either a benefit or a detriment to man and, since the turtle is too small to be considered as a table delicacy, the spotted turtle has no dollar and cents value to man. It is not a scavenger.

PARASITES.—Because of its habitual visits to the land and on account of its habit of sunning itself for long hours out of water, this species is less infected with leeches than most of our water turtles, though leeches are usually abundant in its favored environment.

TABLE 6.—MEASUREMENTS OF ILLINOIS SPECIMENS OF *Clemmys guttata*
(Measurements in millimeters)

Specimen No.	Carapace		Plastron			Head	Tail		Sex
	Length	Width	Length	Width	Depth		Total	A-T	
1........	109	87	99	71	40	16	26	20	♀
2........	114	76	95	68	40	16	31	25	♀

GENUS EMYS DUMÉRIL

Emys (part) Duméril 1806
Terrapene (part) Bell 1825
Cistudo (part) Gray 1831
Lutremys Gray 1855
Emyoidea Gray 1870
Emys plus Emyoidea Baur 1889
Neoemys Lindholm 1929

Plastron united to the carapace by a ligamentous attachment. Plastron divided by a ligamentous hinge between the pectoral and abdominal scutes (between the hyosternal and hyposternal elements of the endoskeleton) into two movable lobes; hind lobe truncate posteriorly or with but a shallow notch, and smaller than the aperture. Humero-pectoral suture overlying the entoplastron. Skull with a bony temporal arch; alveolar surfaces of the jaws without a median ridge; choanae between the eyes very large; dorsal surface of the head covered with undivided skin and without plates of any kind. Webs of feet extending to the claws.

Emys blandingii (Holbrook)
(Blanding's turtle; glass turtle)

Cistuda blandingii Holbrook 1838
Lutremys meleagris LeConte 1854
Emys meleagris Agassiz 1857
Emys blandingii Strauch 1862
Emydoidea blandingii Gray 1870
Neoemys blandingii Lindholm 1929

DESCRIPTION.—The following description is taken from an exceptionally beautiful and unusually large specimen (carapace length, 240 mm). Shell oblong, moderately high but with the carapace flat dorsally, not arched or domed. Vertebral scutes large and wide. First vertebral

pentagonal, the sum of the two anterior faces exceeding considerably the length of the posterior margin, and meeting these borders at the median point in such a wide obtuse angle as to approach a straight line. Second, third, and fourth vertebrals much wider than long, especially the third; they are hexagonal, with the margins remarkably straight except for the anterior margin of the second and the posterior margin of the fourth, which are dished. The fifth vertebral is roughly triangular, all sides tending to curve outward. Costals large, tending toward the square. The second is the largest of the series; the fourth the smallest. There is a faint trace of rough, concentric striae at the outer margins of the scutes. Marginals 27 in number, with an even edge and no emarginations. There is a wide notch between the caudal marginals. Nuchal long and very slender. Plastron distinctly oblong, truncate anteriorly and with the wide posterior emargination. It is composed of two lobes separated by a ligamentous hinge between the pectorals and abdominals. The posterior lobe is larger than the anterior and forms a ligamentous union with the marginals. Gulars sharply triangular. Humerals tend toward the triangular, but are truncate at the interhumeral suture, which is the shortest of the median articulations. Pectorals oblong or rectangular, as are the abdominals, and these two scutes are of very nearly the same size. Femorals much wider at their lateral margins than at the median suture, the posterior margins being curved to receive the anal scutes. Anals large and with a wide notch involving the entire posterior margin of the scute. Bridge very small indeed, and neither the pectoral nor abdominal scutes enter into its composition, it being represented by the ligamentous hinge between these elements and the marginals. Axillary very small and rudimentary; inguinal absent. The head is medium in size, flat dorsally, and covered with a smooth, tightly drawn skin. Cutting edge of the jaws almost straight, the upper with a wide but shallow median notch, the lower slightly upturned at the symphysis. Nostrils terminal and very close together. Neck long. Anterior limbs covered with strong, transverse scales on their anterior surface; digits five, the outer four with a strongly curved claw each, the fifth with but a rudimentary claw. Posterior limb larger than the anterior, covered with small scales, and with a projecting scale in place of the fifth digit; the remaining four digits with strongly curved claws. Tail long.

COLORATION.—Carapace black or dark brown, with an intricate pattern of pale yellow spots and dashes radiating from a center at the posterior-median margin of the scute. The ground color of the vertebral series is black, while on the costal and marginals, particularly of the anterior two-thirds of the shell, the ground color is pale yellow with the intricate pattern in black upon it. These two arrangements of color intergrade imperceptibly at the vertebral-costal suture, and the carapace is much

PLATE 10.—*Emys blandingii: A,* A very large adult, ventral view. *B,* Same individual, dorsal view. *C,* Newly hatched young, lateral view. *D,* Immature individual, length three and a quarter inches, dorsal view. *E,* Adult, lateral view. *F,* Head study of an adult.

lighter in color anteriorly than posteriorly. Plastron brownish yellow, blotched asymmetrically with great areas of black, these more pronounced at the lateral margin of the scutes. Head brownish olive above, finely mottled with irregular black lines, increasing in number posteriorly. Neck the same color as the head. Under parts of head and neck bright yellow. Upper jaw edged with black; lower jaw yellow. Legs dark above, lighter below, each scale tending to show a black spot.

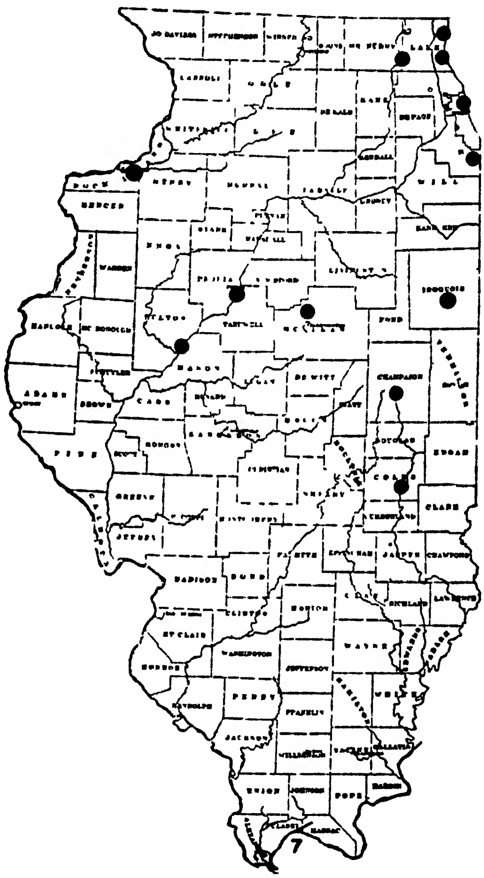
Few specimens that I have ever seen exhibit the perfection of markings shown by the specimen just described. Often the markings on the carapace are obscure or even absent, as in a specimen taken at the southern tip of Lake Michigan, in which there is no trace of color markings whatsoever. This specimen is mahogany brown above, mottled irregularly with large areas of black.

YOUNG.—The newly hatched young have apparently not been described in detail, and the writer failed in his efforts to obtain specimens for this purpose. Fowler (1906) says that they are "nearly circular and black." Through the courtesy of Dr. Loveridge of the Museum of Comparative Zoology, I have been able to borrow and to photograph their young specimen (#1634) which is the original of Agassiz' figures 20-22, plate 4 (1857). This little specimen is black, without markings on the carapace, the surface of which is granular; the plastron shows a *central* black area covering most of the surface, and a thin light peripheral area which probably was yellow. The plastron is one and one-half times the length of the tail. In the writer's collection is a specimen with the carapace length 66 mm. A strong vertebral keel is evident, this highest on the fourth vertebral scute. Each dorsal scute has a posterior median area sharply demarked, and this exhibits a coarsely granular or porous surface. From this area, radiating streaks of yellow extend over the rest of the scute. The keel shows yellow areas. The plastron is yellow, with symmetrically placed areas of mahogany brown on each scute. In this specimen the wings of the pectoral and abdominal scutes form a short bridge terminating in the ligamentous hinge. Top of the head brown, spotted with yellow.

SEX DIFFERENTIATION.—The tail of the male is longer than that of the female; in the male the shell is three times the length of the tail, or less, while in the female it is four times the length of the tail.

GEOGRAPHIC DISTRIBUTION.—*Emys blandingii* is a northern species with a range covering the northern quarter of the United States from New England on the east to Iowa and Minnesota on the west. While nowhere really abundant, the center of its abundance apparently lies in northern Indiana, from which region its numbers grow less as the range extends both east and west. Ditmars (1908) says that "eastward of the Central States it is comparatively rare, though the range extends into the

Alleghanean region and northeastward through Pennsylvania and New York into Massachusetts, Rhode Island and New Hampshire. The species does not occur near the coast regions of New York, Connecticut or New Jersey." It is not common anywhere in New England, though there are scattered records over most of Massachusetts (Babcock). Surface (1908) considers it rare in Pennsylvania, and does not give any specific locality records. The first Pennsylvania record is that of Stewart (1928) for Lewisburg, and Netting (1932) adds two more; hence it must be considered rare in that state. Morse (1904) reports that it is nowhere abundant in Ohio, but says that it is found in streams flowing into Lake Erie and into the Ohio River. In Michigan, Ruthven *et al* (1912) report it from numerous counties in the southern part of that state. For Indiana, the state in which most authorities claim it is most common, Hay (1892) says that it is found only in the lake region of the northern part of that state, while in his "Preliminary Catalogue" he says "it is found sparingly in northern Indiana." For Wisconsin, Hoy (1883) reports it as "abundant on the prairies;" Higley (1889) says it is common, and Pope and Dickinson (1928) record specimens from nine counties. In Iowa, Blanchard (1922) reports a specimen from Dickinson County, mentioning that this record is the most westerly for the species, as well as the first for Iowa. It is reported by Nash from Ontario, Canada.



MAP 7.—*Emys blandingii.*

ILLINOIS RECORDS.—It is of especial interest to note that the type specimen was taken by Holbrook (1838) from "The Fox River" in Illinois, this being the only species of turtle the type specimen of which was taken in this state. Kennicott (1855) reports it as "common on the prairies." Garman (1890) reports of this species that "as late as 1870 it was rather common about water on the prairies of central Illinois; it is now very rare, only one example having been taken in the past six

years." Two years later Garman reports it as "throughout the state, commoner north; rare at present," and records specimens only from Normal and Urbana. There is no evidence to bear out the statement that *Emys blandingii* has this distribution in the state—at least not at the present time—and it is extremely doubtful whether it ever occurred throughout the state. Hankinson (1917) reports it from Charleston, and Weed (1922) records it as "abundant" in the Chicago area. In the Field Museum are specimens from Lake Forest (#2435), Meredosia (3403, 3427), Chicago (3247), as well as seven eggs from Waukegan (5953). The writer has examined specimens from the following Illinois localities: Peoria, Havana, the Illinois-Mississippi canal near Rock Island, Meredosia, Cook County, and Charleston. The Illinois River at Meredosia yielded three specimens, including the large one described, while the other localities yielded a single specimen each. It is a rare turtle over most of northern Illinois, and absent from the southern half of the state.

HABITAT.—This species shows a considerable amount of variability as to its mode of life and habitat preference. Speaking in general terms, *Emys blandingii* is a semi-aquatic turtle: in certain regions it is largely a terrestrial species, while in others it is almost entirely aquatic in its habits. Thus in the region south of the tip of Lake Michigan the individuals of this species tend to spend a great amount of time out of water, wandering about in the fields, woods, and sandy areas quite far from water. In the region about Meredosia on the Illinois River, individuals are not ordinarily found far from the water, the turtles spending most of their time in the river itself or in either the tributary streams or adjacent swampy areas. Thus Garman (1892) says that it is oftener found in water than on land, but that it is essentially a terrestrial species—a rather curious mixture of ideas. The original habitat seems to have been the wet prairie regions of the state, but the draining of the soil and the cultivation of the fields have so altered the pristine conditions that the turtle has become extinct over most of what was originally its primary range. This would account in a measure, then, for the diverse habitat selections we find today, some individuals of an original swamp species attempting to adapt themselves to the dry land conditions they find, others taking to a more aquatic existence where large rivers and an abundance of water afford such an environment.

HABITS.—There is probably no turtle found in Illinois whose habits and life history are less known than are these phases of the life cycle of *Emys blandingii*. Apparently not a common species anywhere, it has been largely neglected. Yet there has been a considerable amount of work done on the only other species of this genus, *Emys orbicularis* of southern and eastern Europe and southwestern Asia and northern Africa.

Incidentally, this curious distribution of two such closely related turtles (*Emys orbicularis* formerly ranged over Germany, Holland, Denmark, and the British Isles) is explained on the theory of old "land bridges" said by geologists to have existed during the Mesozoic and Cenozoic eras and as recently as the Pleistocene. Of especial interest in this distribution are the postulated bridges between America and Europe across Greenland and Iceland on the east and the Asiatic bridge across what is now the Bering Strait on the west.

Blanding's turtle is very timid by nature. When frightened while sunning along the shore of the lake or upon a log in the pond, it plunges at once into the obscurity of the water and remains for hours hidden and withdrawn. Eventually it gathers enough courage to poke its eyes out of water, and then scrutinizes the surroundings with exceeding care before venturing upon further exposure. If surprised on land, it withdraws at once into its shell, which it closes as tightly as possible, and there it remains sealed and quiescent for a long time. If things remain quiet, the anterior lobe is slowly opened a crack so that the turtle can see out; if this experiment proves successful, the opening is increased and the head slowly, almost imperceptibly protrudes for a better view, and only after long deliberation will the turtle venture further. Morse (1904) makes the rather curious observation that once the turtle has withdrawn within its shell "no amount of thumping will cause it to open the hinged plastron" from which he assumes the very timid nature of the species. No amount of "thumping" will cause any turtle to forsake the protection which its shell affords.

Though entirely at home on land, where the hinged plastron affords it efficient protection, *Emys blandingii* is an excellent swimmer, holding its own in all aquatic requirements with any of the species of pond turtles. Its underwater movements are fast and decisive; it swims with bold strokes that carry it forward with good speed. The bottom vegetation offers it hiding facilities which it utilizes when disturbed, and it may on occasion be seen walking slowly about on the bottom in search of food. It can hold its breath with any of the pond turtles, and is capable of remaining under water fully as long as species of the genus Chrysemys. The variegated pattern and peculiar shading of the carapace blends well with the light and shadow of the vegetation.

As to the hibernating period, there is also little information, due to the rarity of the turtles. Apparently they go into hibernation early, and come out rather late. The long period of inactivity is spent under water in many cases, and often in the mud at the bottom of the pond. Specimens have been taken at Meredosia from the underwater runways of the muskrat *(Ondatra zibethica)* and also from the mud of springfed

ditches. They are most often found while in hibernation by the probing method used to locate turtles during the winter, and the curious name of "glass turtle" arises from the peculiar glass-like sound caused by the steel point of the probe hitting the carapace of the turtle.

NESTING HABITS.—In the literature, information on the nesting and breeding habits is confined to quotations from Agassiz as to the number of eggs laid, and very little else besides. Gadow (1901), however, has some interesting notes on the very closely allied *Emys orbicularis* which, since the species are very closely similar besides being the only two representatives of the genus in the world, may, perhaps, be of some interest, though whether they are relevant or not must be left to the future to determine.

> During the pairing season, on warm spring nights, they emit short piping sounds, and when they have found each other, the couple swim about together. The white, hard-shelled, long, oval eggs, averaging 25 to 15 mm, and about ten in number, are laid on land. This is a very laborious and curious business. The female having selected a suitable spot, not loose sand, but rather hard soil free from grass and other dense vegetation, prepares the ground by moistening it from the bladder, and the anal water-sacs. Then it stiffens the tail and bores a hole with it, moving the tail but not the body. The hind limbs then scoop out the hole, the broad feet moving alternately and heaping up the soil on the side, until the hole is about five inches deep, that is as far as the hind legs will reach. The eggs are laid at the bottom in one layer, divided and distributed by the feet. Lastly, the soil is put in again and the tortoise, by repeatedly raising its body and falling down, stamps the soil firm and flat, roughens the surface a little with its claws, and leaves the nest to its fate. Nothing but an accident leads to its discovery. The young are hatched, according to locality and the kind of season, either in the same autumn or not until the next spring.

EGGS.—The eggs number from 6 to 10, though the ovaries of a large female will be found to contain hundreds of eggs of various sizes, these, of course, being the supply for future years. The eggs when laid are covered by a tough, white, unglazed shell. The average size of eight eggs which composed the complement removed from the oviduct of a large female just about to lay is 36.6 mm by 25.2 mm. The largest egg was 38 mm by 26 mm.

INCUBATION.—If *Emys blandingii* resembles *Emys orbicularis*, it is altogether possible that the eggs do not hatch until the spring following their deposition, passing the winter with a retarded metabolic rate so far as the embryo is concerned. Agassiz has hinted in several cases that this may occur, and experimentation and investigation of this phase of testudinate development would be of great interest.

FOOD HABITS.—Unlike other species of pond turtles, Blanding's turtle apparently feeds readily both on land and in the water. On land it eats grasses, leaves, berries, and other succulent vegetation with relish, and

has no difficulty in swallowing this food in the absence of water. Insect larvae, grubs, slugs, and earthworms vary the vegetable diet on land, the animal matter composing about 30 per cent of the contents of the only "terrestrial" stomach available to the writer for study. In their water environment they feed with equal avidity upon frogs, tadpoles, crayfish, minnows, and the larger larvae of aquatic insects. It speaks well for the speed of this turtle to note that it catches these active forms with apparent ease and surety. Also it is interesting to note that this species is able to swallow food both under water and while on land.

TABLE 7.—MEASUREMENTS OF ILLINOIS SPECIMENS OF *Emys Blandingii*
(Measurements in millimeters)

Specimen No.	Carapace		Plastron			Head	Tail	Sex
	Length	Width	Length	Width	Depth			
1........	240	164	220	116	83	38	103	♀
2........	172	122	170	98	63	28	65	..
3........	64	50	50	40	26	13	25	..

ECONOMIC IMPORTANCE.—This turtle is far too rare to have any economic value to man, but there is an abundance of good meat on it, which is both palatable and of excellent flavor. It is never a scavenger by habit, and its innocuous food habits certainly cannot be damaging to man.

PARASITES.—Though I have examined only three Illinois specimens, I have failed to find any trace of either trematode or nematode parasites, nor any evidence that the species is seriously attacked by leeches.

GENUS TERRAPENE MERREM

Terrapene (part) Merrem 1820
Cistuda (part) Flemming 1822
Cistudo Bonaparte 1830
Emys (part) Wagler 1830
Diclida (part) Rafinesque 1832
Pyxidemys (part) Fitzinger 1835
Emyoides Gray 1844
Onychotria Gray 1849
Pariemys Cope 1895
Toxaspis Cope 1895
Didicla Fowler 1906 (= Diclida Raf.)

Shell high, globular, convex. Plastron large, completely filling the aperture, rounded anteriorly and posteriorly, and united to the carapace by a ligament and movable upon it. Plastron divided into two movable lobes by a transverse hinge between the pectoral and abdominal elements; axillary and inguinal scutes rudimentary. Humero-pectoral suture meeting the entoplastron at about its middle. Dorsal surface of the head covered by smooth skin only. Alveolar surface of the jaws narrow and

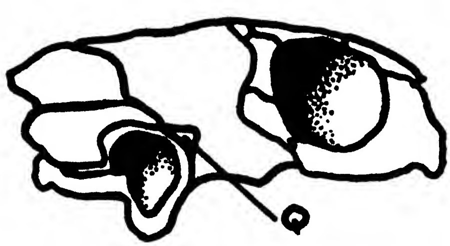
without a median ridge; upper jaw with beak projecting downward. Choana between the eyes large; no bony temporal arch present. Digits with but a slight web or none. Tail very short.

Terrapene carolina carolina (Linnaeus)
(Common box turtle; sand turtle)

Testudo carolina Linnaeus 1758
Testudo carinata Linnaeus 1758
Testudo brevi-cauda Lacépède 1788
Testudo clausa Gmelin 1788
Testudo incarcerata Bonnaterre 1789
Testudo incarcerata-striata Bonnaterre 1789
Testudo virgulata Daudin 1802
Emys clausa Schweigger 1812
Emys virgulata Schweigger 1812
Emys schneideri Schweigger 1812
Cistudo clausa Say 1825
Terrapene clausa Merrem 1820
Terrapene carolina Bell 1825
Terrapene maculata Bell 1825
Terrapene nebulosa Bell 1825
Terrapene virgulata Fitzinger 1825
Emys carolina Gray 1831
Cistudo carolina Gray 1831
Pyxidemys schneideri Fitzinger 1835
Pyxidemys virgulata Fitzinger 1835
Pyxidemys clausa Fitzinger 1835
Cistudo virginea Agassiz 1857
Terrapene carinata Strauch 1862
Cistudo clausa clausa Cope 1875
Cistudo carinata S. Garman 1884
Cistudo carolina carolina H. Garman 1892
Didicla (= Diclida) *carolina* Fowler 1906

Description.—The range of variations of shape, markings, and color of *Terrapene carolina carolina* is almost unlimited, so that any two specimens are hardly more than similar even though they have come from the same locality. So infinite are these variations that I can do no better than to describe a typical specimen and indicate the range of various characters. The shell is usually oval, somewhat narrower toward the anterior end than toward the posterior, but in some cases the individuals are nearly round. Carapace highly convex, arched, globular, the marginals entire over the anterior two-thirds of the carapace, but tending to become serrate in the posterior third, with a conspicuous though small caudal notch. Vertebral scutes of moderate size. The first vertebral is pentagonal, the two anterior margins tending to unite medially in a point which intrudes into the posterior margins of the first paired marginals. Second and third vertebrals hexagonal, the anterior and posterior margins almost equal and longer than those of the remaining four sides which are approximately equal. The fourth vertebral tends to be heptagonal in some specimens, hexagonal in others, the variation occurring in the anterior margin. Fifth vertebral, the smallest of the series, roughly hexagonal and wider than long. There is a distinct, though low and blunt, vertebral keel, most conspicuous on the second, third, and fourth scutes. The anterior three costals are large. The first is trapezial in shape, the dorsal (median) margin being the shortest. Second costal the largest of the series, rectangular. Third costal roughly rectangular and somewhat smaller than the second. Fourth costal by

far the smallest of the series and about the size of the fifth vertebral, tending toward square. Nuchal small or (rarely) absent. Anterior and posterior marginals flaring, the posterior more so than the anterior, though the caudals are nearly vertical; edge entire up to about the eighth scute where serration usually begins. There are twelve paired marginals. All scutes of the carapace with finely etched concentric lines. The focus of these lines lies at the posterior median border of the vertebral scutes, in the center of the dorsal third of the costals, and at the posterior-lateral angle of the marginals. Plastron large, completely closing the aperture. It is divided into two lobes by a ligamentous hinge between the pectoral and abdominal scutes, both lobes being movable. It is attached to the carapace by a ligamentous hinge in lieu of any trace of a bridge. Gulars large, triangular. Humerals a truncate triangle, the interhumeral suture being short. Pectorals rectangular and approximately twice as wide as long. Abdominals also rectangular, larger than the pectorals. Femorals very large, triangular, the interfemoral suture being the shortest of the ventral sutures, and the plastron is widest across the femorals. Anals very large, triangular, the interanal suture the longest of the ventral median contacts, and without an interanal notch. There is a tendency to show concentric striae on the plastral elements, but these are usually nearly worn off; the focus of these is at the posterior lateral angle of the scutes. The mid-ventral suture tends to be a straight line, with few undulations. Axillary and inguinal elements usually absent, or at best very rudimentary. Head of medium size, covered with a smooth, tightly drawn skin. Upper jaw hooked, entire, *without* a notch at the symphysis; lower jaw with an upward hook. Alveolar surfaces narrow and without a median keel or ridge. Limbs and feet strong, scaly; digits with very rudimentary web, or free. Claws of the fore feet short, but strong and five in number; four claws on the hind feet, longer than those on the fore. Tail short and stubby. Of osteological characters, Taylor (1895) points out that the zygomatic arch is absent; the quadrato-jugal is rudimentary and triangular, articulating only with the quadrate; post-orbital arch wide, the jugal being relatively wide and short; phalanges: fore limb 2-3-3-3-2 or 2-3-3-2-2; hind limb; 2-3-3-3-2.



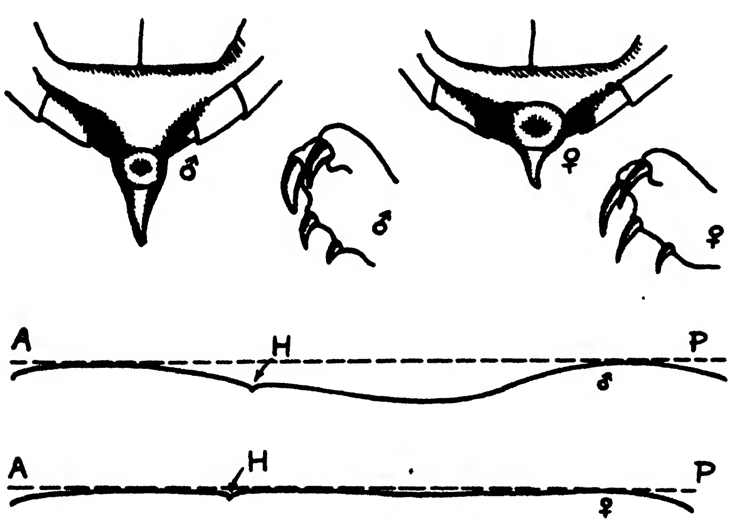
TEXT-FIGURE 11.—The skull of *Terrapene carolina carolina*. *Q*—quadrate.

COLORATION.—Extremely variable. The carapace is dark brown or nearly black, with blotches, stripes, and hieroglyphics of yellow or orange. Sometimes the yellow predominates, sometimes the dark brown

PLATE 11.—*Terrapene carolina carolina: A,* Adult male, ventral view. *B,* Same individual, dorsal view. *C,* Newly hatched young, ventral view. *D,* Newly hatched young, dorsal view. *E,* Head study of an adult. *F,* Adult, lateral view.

ground color. While the yellow markings are extremely irregular, the tendency or plan is for them to radiate from the center of the growth point of the scute. The vertebral keel is marked by either a yellow line or a series of elongated yellow blotches. The plastron varies from clear yellow to clear ebony black or mahogany brown, with every conceivable variation between. Sometimes the colors are demarked into distinct areas of solid color; sometimes the entire plastron is intricately mottled. Soft parts brown, sparsely or heavily marked with round spots of yellow or orange, particularly about the neck and fore limbs. Jaws yellow, with black spots or lines. Iris varies from brown to bright scarlet.

YOUNG.—The young are much more round than the adults and the vertebral keel is far more distinct and considerably higher in proportion. Each vertebral scute tends to have a yellow spot on the portion of the keel associated with it, and there is a similar yellow spot on each costal, while the marginals usually have a yellow mark (not a round spot) at their lateral margins. I have one young turtle of this species which does not have a trace of the usual spots on the carapace. The color of the carapace is, otherwise, uniformly brown. Plastron yellow, with a large central area of dark brown occupying most of it. The tail is relatively larger in the very young than in the adults.



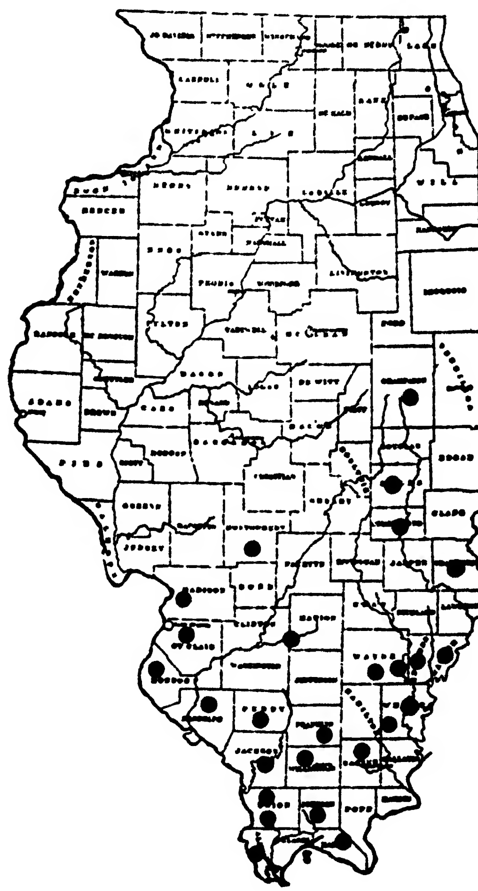
TEXT-FIGURE 12.—Sex differentiation in *Terrapene carolina carolina*. *(Above)* Ventral views of the tail and of the right hind foot, male and female. *(Below)* Diagrammatic longitudinal sections through the plastron, male and female. *A*—anterior; *H*—hinge; *P*—posterior.

Sex Differentiation.—There are a number of secondary characters which are associated with the sex of the individual, and these may be listed as follows: (1) The tail of the male is longer than that of the female, the difference lying in the distance of the anus from the plastron, not in the distance from the anus to the tip. (2) Hence the anal aperture opens beyond the carapace in the male, and below the carapace in the female. (3) The claws of the hind foot of the male are short and stocky and considerably curved; in the female the claws are longer, more slender and less curved. (4) Plastron of the male is concave in the anterior region of the hind lobe just posterior to the hinge; no such concavity exists in the female. (See Text-fig. 12 for diagrams representing longitudinal cross sections through the plastron.) (5) The carapace of the male tends to have a greater flare at its posterior corners than is the case in the female. (6) The nuchal notch is more marked in the male than in the female. (7) Relative height and width of the male is greater than of the female. (8) The iris of the male tends to be red or pink; of the female yellow or brown. (This is generally but not always true).

Geographic Distribution.—The range of *Terrapene carolina carolina* includes the major portion of northeastern United States, extending as far north as the Great Lakes and the St. Lawrence River. It occurs over most of New England, including the coastal states of Maine, Massachusetts, and New Jersey, and extending southward to Georgia. The western limit of its range lies in Wisconsin, Illinois, and Missouri. In Pennsylvania (Surface, 1908) it is found to be statewide, excepting for the pine barrens country, where it is absent. Morse (1904) reports that, while nowhere abundant in Ohio, it is to be found over the entire state, and Hay (1892) reports a similar distribution for Indiana. Ruthven *et al* (1912) report it from several southern counties in southern Michigan. Blanchard (1922) reports it from western Tennessee, while Hurter (1911) reports but a single specimen taken from the west side of the Mississippi, in Missouri. In the northwestern portion of its range it is reported from southern Wisconsin as far north as Green Bay by Pope and Dickinson (1928), although Higley (1889) fails to mention it for that state, while Cahn (1929) adds one record for southern Wisconsin. There is no ground for the statement by Pope and Dickinson that it is probably "statewide" in its distribution in Wisconsin.

Illinois Records.—Within the state of Illinois there are records of the box turtle, *Terrapene carolina carolina*, from numerous localities. Yarrow (1882) reports specimens from Mt. Carmel (9512) and Fairfield (9939) in the U. S. National Museum. Garman (1892) records it from Duquoin, Eldorado, Cobden, Anna, Fairfield, and Mt. Carmel. Hurter (1911) found it in Madison, Monroe, St. Clair, Randolph and Union

counties in the Mississippi River region; Hankinson (1915, 1917) reports it from the Charleston region, Blanchard (1924) in Johnson and Monroe counties, and Shenck (1886) has some interesting notes from Albion. The Field Museum has a specimen from Olive Branch (2219). Gaige (1914) reports *T. carolina* from Richland county, but in a personal letter this is corrected, the specimen proving to be *Terrapene ornata.* The present writer has examined specimens from the following localities: Centralia, Robinson, Toledo, Anna, Cobden, Mt. Carmel, DuQuoin, Alto Pass, Litchfield, Norris City, Urbana, Carmi, Benton, Marion, Charleston, and Carbondale.



Map 8.—*Terrapene carolina carolina.*

Habitat.—The common box turtle is distinctly and preëminently a woods species, essentially terrestrial in its habits, yet, as we shall see later, with certain aquatic or semi-aquatic inclinations. Its favorite haunt is in dry deciduous woods with plenty of underbrush and herbaceous ground cover. Here the turtles wander in search of food by day and seek shelter under the protection of the brush at night. Again, the turtles wander out into the grassy fields or into areas under cultivation. Hillsides afford a congenial environment, especially those with a southern exposure, where the early spring sun limbers them up after hibernation.

Habits.—Because of the very gentle nature possessed by these turtles and the ease with which they adapt themselves to confinement they have been much studied and watched, and there is a considerable literature on their general behavior. The box turtle is of a very timid disposition. If discovered, it freezes in whatever position it happens to be, and awaits further developments without a movement. If the danger approaches, it withdraws its head within the shell with a hissing sound caused by the expulsion of the air from the lungs necessary to accommodate the inclusion of the head and neck within the limited space available. The legs

are drawn in, after which the front and hind lobe of the plastron are closed tightly, and the turtle is impregnable. So tightly do the lobes close the aperture that it is impossible to insert a knife blade into the crack if one would pry a lobe free: one is far more likely to break the blade than to succeed in opening the shell. Again, if the turtle is teased too much, it is likely to resort for a time to snapping and feeble lunges, especially during the breeding season when the males seem to develop somewhat of a temper. Under "domestication," however, both the temper and the timidity are quickly overcome, and the turtle soon learns to eat eagerly from the hand that offers food.

Hibernation begins with the cooler weather of late October. At first the turtles dig in at night only and come out during the warmer portions of the day, but as the days grow cooler the turtles remain longer and longer in their holes until they fail to appear at all during the daytime. At first they do not bury themselves to a depth of more than a few inches. As the weather grows colder they work themselves further and further into the ground until they have gone down from a foot to eighteen inches or even to a depth of two feet. The following tabulation shows the progressive depths of hibernation as found by the writer by probing down to a turtle known to be hibernating:

Date	*Depth* (in inches)	*Date*	*Depth* (in inches)
October 21	2	November 25	16
October 28	5	November 30	19
November 4	5	December 5	19
November 11	9	February 9	19
November 18	11		

If taken out of hibernation the turtle is to all appearances dead, but in the proximity of heat it slowly revives and in a few hours is looking around inquisitively. The species comes out of hibernation in April, the exact time depending largely upon the weather. If a late cold spell descends upon the turtles after they are out, many die of exposure: apparently their adjustment to the environment is a rather slow process.

A great deal has been written both about the avoiding of water by the box turtle and about the aquatic habits of the species. The belief is firmly fixed in the popular and scientific mind that the box turtle avoids water, and the appearance of many brief notes, many written apparently in a spirit of astonishment, calling attention to a turtle found somewhere associated with water have failed to make much of an impression. The significance of these notes, namely, that *Terrapene carolina carolina* has a distinct use for and attraction to water has not yet filtered through the consciousness of the writers. Yet such is the case. During the hot

periods of the summer we find the box turtle going into a state of aestivation closely akin to its period of hibernation, during which it remains quiescent, buried in the ground. Often this aestivation is passed buried in mud, as noted by Hurter (1911), Overton (1916), Engelhardt (1916), and others. The site is usually a mudhole, and in the wet mud, buried to a depth of from two inches to nearly a foot, the turtles spend the periods of excessive heat. If the space is limited, the turtles pile up on top of each other, and Hurter reports six taken from a space three feet in diameter. Latham (1916) reports a regular procession of box turtles heading toward a small mudhole in August, with sixty to seventy individuals already gathered in and about the puddle.

A still more (apparently) unusual use of water by the box turtle came under my observation during the fall of 1931 and the winter following. In the spring of that year I liberated some 24 adult specimens of *Terrapene carolina carolina* and 17 of *T. ornata* representing both sexes in an outdoor pen measuring 40 by 12 feet. At one end a pipe poured a steady stream of water, forming a puddle six inches deep and about a yard in extent. In late October all of the *T. ornata* went into hibernation and were seen no more until spring. It was a very mild fall, and *T. carolina carolina* did not begin to think about hibernation until November 2, and soon afterward all went into the ground except five specimens, which about this time took up their abode in the water and were apparently quite contented in the puddle. The interesting part is that these remained in the water the entire winter, occasionally poking their noses out for air on the milder days, but remaining almost immobile during the three months of winter. On a particularly mild day in January one specimen came out on the land, and went in again in the afternoon; the air temperature of this day was 11° C. Two days later (January 29), one went for a walk and got too far from the water; it was found frozen to death the next day. The following data in regard to one of these water-hibernating turtles are of interest: air temperature, 3° C; water temperature, 10° C; body (rectal) temperature, 9.5° C. Subsequent readings showed that the body temperature remains about 1° C below that of the surrounding water.

The box turtle is capable of swimming and is, in fact, quite good at it, though because of the globular form of its shell and the shortness of its legs, swimming is an awkward and laborious process. It swims at the surface, with the dome of the carapace and the head out of water, and I have never seen one swim below the surface; in fact, they seem to be too buoyant to get under. The turtle paddles slowly along, resting repeatedly as it floats at the surface, to continue its progress toward shore at broken intervals. The young seem to be more aquatic than the adults.

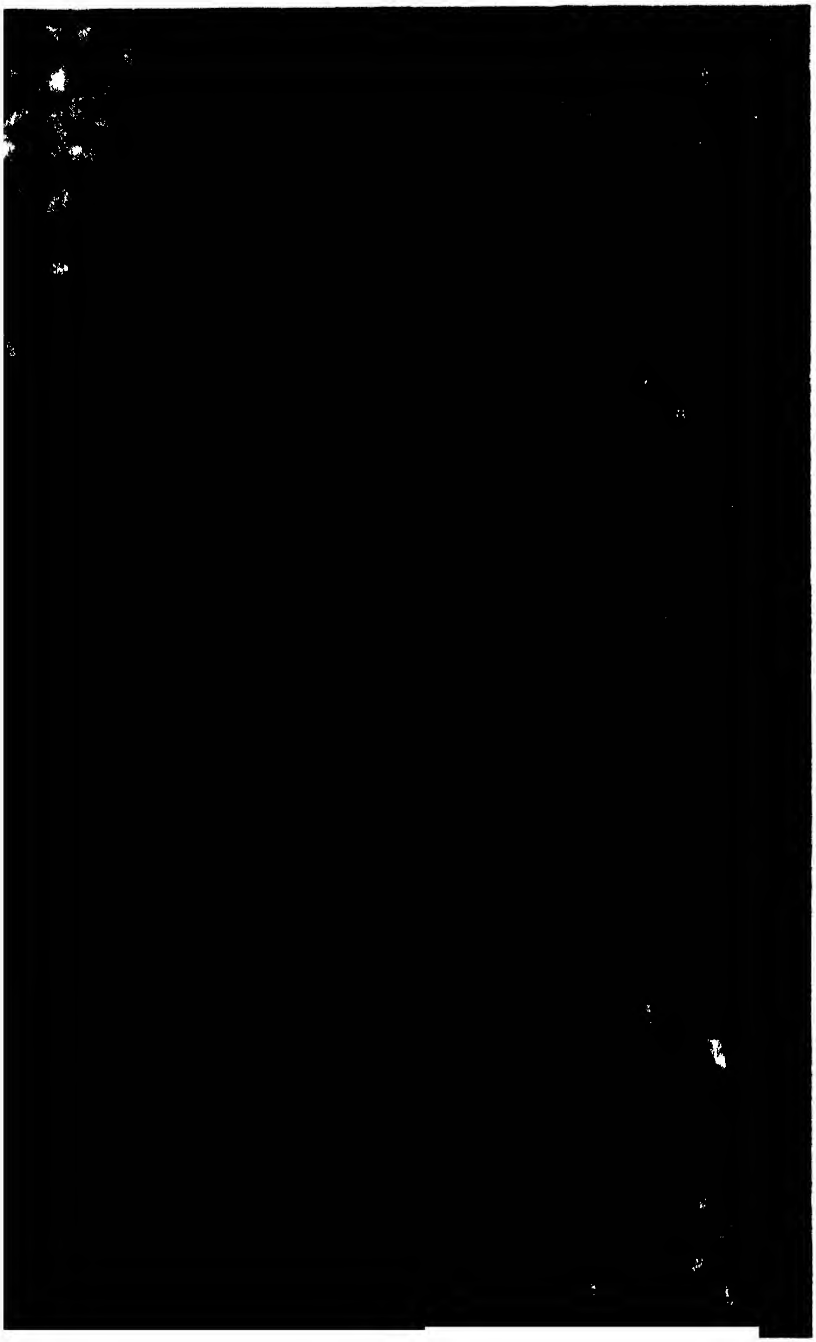


PLATE 12.—*Terrapene carolina carolina:* Box turtles in copulation. The female is on the left, the male on the right.

This turtle leads a rather uneventful, quiet sort of life. During the day the creatures wander about rather aimlessly in search of food. When night comes they sometimes dig into the ground and conceal themselves; with morning they dig out again, working forward, not backing out of the hole by which they entered their retreat. As they eat they grow fat, and specimens taken in the late fall prior to hibernation are likely to be so fat that they are unable to withdraw completely within the shell. They are comical at such times. If pressure be applied at one end of the shell the turtle pops out at the other end as it attempts to withdraw the end that is in danger within the protection of the shell, a procedure which its corpulent condition renders impossible.

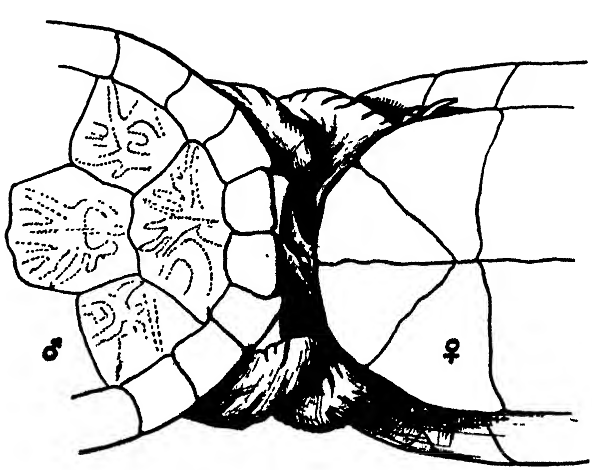
There are a number of interesting notes scattered through the literature which throw some light on the longevity of this species. Thus Dr. Shenck (1886) records an item of interest from Albion, Illinois. A turtle with initials engraved upon its carapace in 1824 was recaptured in 1865, marked with an additional initial and again liberated. It was recaptured again in 1885 within half a mile of the original spot of its capture, still bearing clearly all of the initials. Hence this turtle was 61 years old at least, but to this must be added the fact that it was already fully grown when the initials were first put on in 1824. Initials carved on turtles ordinarily cannot be taken too seriously as proving anything, but this case seems to be authentic. It emphasizes further the fact that the range of the individual box turtle is very limited and that the adults at least are not prone to wander far from "home." Not only are they long-lived, but the fact that they may survive under difficult conditions is indicated by turtles which Dr. R. W. Shufelt kept alive, without either food or water, for an entire year.

Nesting Habits.—Copulation takes place very shortly after the animals emerge from hibernation, the male mounting the female for a considerable period of time, after having subdued her by a rather vicious attack during which the beak and front feet are effectively used. The act of copulation has been described by Cahn and Conder (1932). The pair described was found in copulation, the male standing nearly erect upon the posterior end of his carapace, his legs pressed firmly into the inguinal area of the female, being assisted in this by the female which, her legs outside those of the male, pressed his legs yet more firmly in place. This represents a sort of "posterior amplexus." How long the pair had been thus in contact is unknown, but they remained thus for an hour and three-quarters, during which time they were handled frequently and photographed. This report is confirmed by Ewing (1933).

Prior to the act the male may follow a given female for days. After copulation the male remains as if exhausted, immobile for several hours, while upon the female the process seems to have no effect whatever.

The nest is made usually in sand, but eggs have been found deposited in the rich agricultural soil of cultivated fields. The nest is dug entirely with the hind legs, and requires several hours for completion, for the work is done leisurely. It is between three and four inches wide and extends into the ground a distance of three or four inches. The female backs into the hole as she digs and continues until she is nearly below the surface of the ground. In this excavation she deposits from three to eight eggs, five to seven being the average number. Each egg is worked into its proper position after it is laid, and by manipulation with the hind feet, each is buried separately. It takes about three-quarters of an hour to complete the laying of the eggs. When the last egg is concealed, the turtle fills up what remains of the hole, smoothing the surface and eradicating all signs of the nest by dragging the plastron over the ground several times. The period of incubation is about three months. Females of the species, liberated in my outdoor pen in early June (at which time dissection of certain ones showed hard-shelled eggs in the oviduct), had the young hatch on October 8. However, this pen was shaded by buildings and by vegetation, and received but little direct sunlight, which may perhaps have lengthened the period of incubation.

It is a well-known fact that, in spite of the abundance of *Terrapene carolina carolina* in certain regions, the newly hatched or partially grown young are but rarely found in nature. The young which hatched in my pen headed immediately toward the puddle of water at one end, entered it and remained hidden in the vegetation and beneath the bottom débris until I fished them out before the cold weather set in. In the laboratory they immediately burrowed under the sphagnum which covered the ground in their little enclosure, and remained embedded in the moist earth



TEXT-FIGURE 13.—Posterior ends of the shells of a pair of *Terrapene carolina carolina* in copulation; ventral view of plastron of female; dorsal view of carapace of male.

for weeks at a time. These facts may well give a clue to the reason for the scarcity of small box turtles. The very young possess a terminal egg tooth which they use in picking their way out of the egg; it is lost within a week after hatching.

EGGS.—The eggs number, as we have said, between three and eight in a clutch. They are oval in shape, the curvature of the ends being equal. The shell membrane is very thin and flexible, the eggs having a soft, pliable feel when handled. The average size of a typical egg is 33.17 mm by 19.5 mm, this figure obtained by measuring 54 eggs of the species. The largest egg in the series examined measured 35 mm by 19 mm; the smallest 30.5 mm by 18.5 mm. Ewing (1933) offers interesting data on the subject of the eggs and incubation period, and shows that for Washington, D. C., "the earliest date of egg laying was June 22; the latest date was July 14. The average date for egg laying was July 1. The average date for the emergence of the first young individual of a nest was September 26. The average number of eggs laid at any one time by a female was 3. The percentage of eggs found to be fertile was 78.6." In a table he shows the incubation period to vary from over 69 days to over 103 days, and from his data one obtains the average incubation period as 88 days.

FOOD HABITS.—The diet of *Terrapene carolina carolina* is a mixture of both vegetable and animal matter, with the former predominating in most cases. The vegetable material consists of a great variety of plants, including the roots, stems, and leaves of a host of species of flowering plants, berries, fruits, and some seeds. Fungi are particularly liked according to a number of authorities, though I have never found evidence of this in specimens examined from Illinois. The animal matter consumed includes earthworms, snails, slugs, myriapods, and a great variety of insect species, coleopterous forms ordinarily predominating. Reports mention the fact that the box turtle is fond of lettuce and of cucumbers and muskmelons and that they sometimes damage these crops; this damage cannot, however, really amount to much. In captivity the young feed well upon bananas, lettuce, apples, and various succulent fruits, but if not permitted to hibernate they cease eating entirely, no matter what enticing morsels are offered them, and death usually follows before the winter is over.

ECONOMIC IMPORTANCE.—The insect-eating proclivities of this species make it a highly desirable turtle to have around, for the diet includes many species of noxious insects—such as cutworms, grasshoppers, caterpillars of various species, ants, flies and their larvae, and several species of injurious beetles. Though usually edible, the box turtle is ordinarily not used for food. Babcock (1919) reports an instance in Pennsylvania

where, during a coal strike, the miners went afield and gathered in box turtles which they ate, and which promptly made them ill. It is assumed that they had fed upon some species of poisonous "toadstool" which rendered the turtles temporarily poisonous, but which did not poison them. This is a more than likely supposition, for the box turtle is particularly fond of fungi of various sorts. It is not at all a scavenger and only rarely or under peculiarly adverse circumstances preys upon other vertebrates of any sort.

Parasites.—Being a terrestrial form, the box turtle is not subjected to attacks of leeches, and intestinal worms are not overly common. I have on two occasions dissected out the large white larvae of a species of botfly imbedded in the neck region. These occupied a cavity nearly half an inch deep, yet seemed to cause the turtle but little inconvenience.

Table 8.—Measurements of Illinois Specimens of *Terrapene carolina carolina*
(Measurements in millimeters; weight in grams)

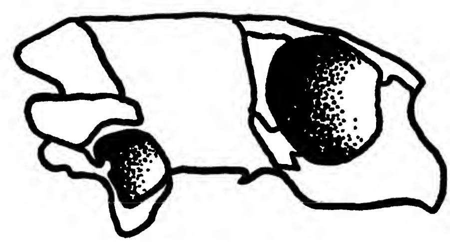
Specimen No.	Carapace		Plastron			Head	Tail		Weight	Sex
	Length	Width	Length	Width	Depth		Total	A-T		
1	134	105	128	75	62	22	36	20	371	♂
2	94	84	93	65	48	16	26	20	169	♀
3	138	108	142	90	75	22	27	24	550	♀
4	137	101	135	75	70	22	27	25	536	♀
5	122	96	118	76	69	20	22	18	317	♀
6	141	111	139	86	73	22	20	15	584	♀
7	141	112	130	80	60	23	35	18	424	♂
8	99	79	96	61	50	17	25	20	166	Im. ♀
9	89	70	84	57	41	18	..	..	116	Im. ♂
10	139	113	132	82	65	23	30	14	452	♂
11	141	112	137	79	60	24	31	14	416	♂
12	125	92	121	77	55	20	35	20	294	♂
13	50	46	48	37	22	10	18	15	27	Im. ♂
14	81	65	80	51	38	15	16	14	106	Im. ♂
15	151	116	141	87	68	21	38	31	620	♀
16	145	110	135	81	66	22	40	18	475	♂
17	140	110	133	82	71	22	36	33	496	♀
18	60	56	57	41	27	12	16	14	31	Im. ♀

Terrapene ornata (Agassiz)
(Painted box turtle; sand turtle)

Cistudo ornata Agassiz 1857
Terrapene ornata Baur 1891
Terrapene ornata cimarronensis Cragin 1894

Description.—Shell broadly oval, the width equalling approximately three quarters of the length. Carapace high, but much flattened dorsally; anterior slope gradual, posterior (caudal) slope abrupt. First vertebral scute pentagonal, the anterior margins meeting in a median point which projects far into the nuchal. Second, third, and fourth vertebrals hexagonal, the width exceeding the length. Fifth vertebral pentagonal, and placed nearly vertically; it is the smallest of the series. There is no

trace of a vertebral keel. Costal scutes large, wider than long. The first costal trapezial, the median dorsal margin the shortest. Second and third costals roughly rectangular, approximately twice as wide as they are long. Fourth costal trapezial, and the smallest of the costal series. Nuchal small, forked posteriorly, the tip of the first vertebral fitting into the V-shaped notch. Anterior and posterior-lateral marginals flaring, the mid-lateral and caudal marginals vertical and without a flare; no inter-caudal notch. Plastron large, but not quite filling the aperture. It is divided into an anterior and posterior lobe by a ligamentous hinge between the pectoral and abdominal scutes, both lobes being movable. The plastron is widest across the abdominal scutes. Gulars acutely triangular. Humerals approaching triangular, with a short interhumeral suture which is usually (though not always) the shortest of the mid-ventral sutures. Pectorals rectangular, the interpectoral suture usually exceeding the interhumeral suture, though this is not always the case. Abdominals rectangular. Femorals trapezial, the interfemoral margin the shortest of the sides. Anals large, the largest of the plastral elements, triangular; their posterior margin is even, straight; and there is no inter-anal notch. The longitudinal mid-ventral suture undulates considerably as small portions of the right and left plastral elements tend to intermesh. The plastron is attached to the carapace by a bridge formed by a very short wing of the abdominals; it is inconspicuous, but distinct. Axillary element large and conspicuous; inguinal either rudimentary or absent. Often the scutes of the carapace show concentric striae about the growth point of each scale; these are more marked on the costals and marginals than on the vertebrals. Similar striae sometimes are in evidence upon the plastral scutes, but usually these are worn off, leaving the plastron smooth. Head rather small, scaly, the dorsal surface covered by a tightly drawn skin. Upper jaw strongly hooked, and with a distinct median notch. Limbs strongly scaled, the scales larger and more prominent on the front limbs. Digits of front limb five, each with a strong, straight claw; digits of hind limb also five (though the fifth is exceedingly rudimentary), the four larger with slender, somewhat curved claws, the innermost being very small and weak. All digits without distinct webbing. Tail short, slender. Osteological features: zygomatic arch entirely absent; quadrato-jugal absent; postorbital arch very slender. Phalanges in fore limb 2-2-2-2-2; in hind limb 2-3-3-3-1.



TEXT-FIGURE 14.—Skull of *Terrapene ornata* (for comparison with Text-fig. 11).

Coloration.—*Terrapene ornata* does not show nearly as much variation in either color or pattern as does *T. carolina carolina.* The carapace is usually a chocolate brown, with local tendencies toward a reddish brown. Each scute of the vertebral and costal series is marked with dashes and lines of bright yellow, which tend to radiate from the growth center. There is a tendency to form a mid-vertebral yellow line, but this is ordinarily somewhat broken up into a series of long yellow dashes. The lateral portion of the marginals bears a yellow patch of irregular shape and of variable size. The plastron is yellow, highly and conspicuously mottled in an elaborate, asymmetrical design of red-brown. Head and neck dark brown, spotted with pale yellow, especially on the

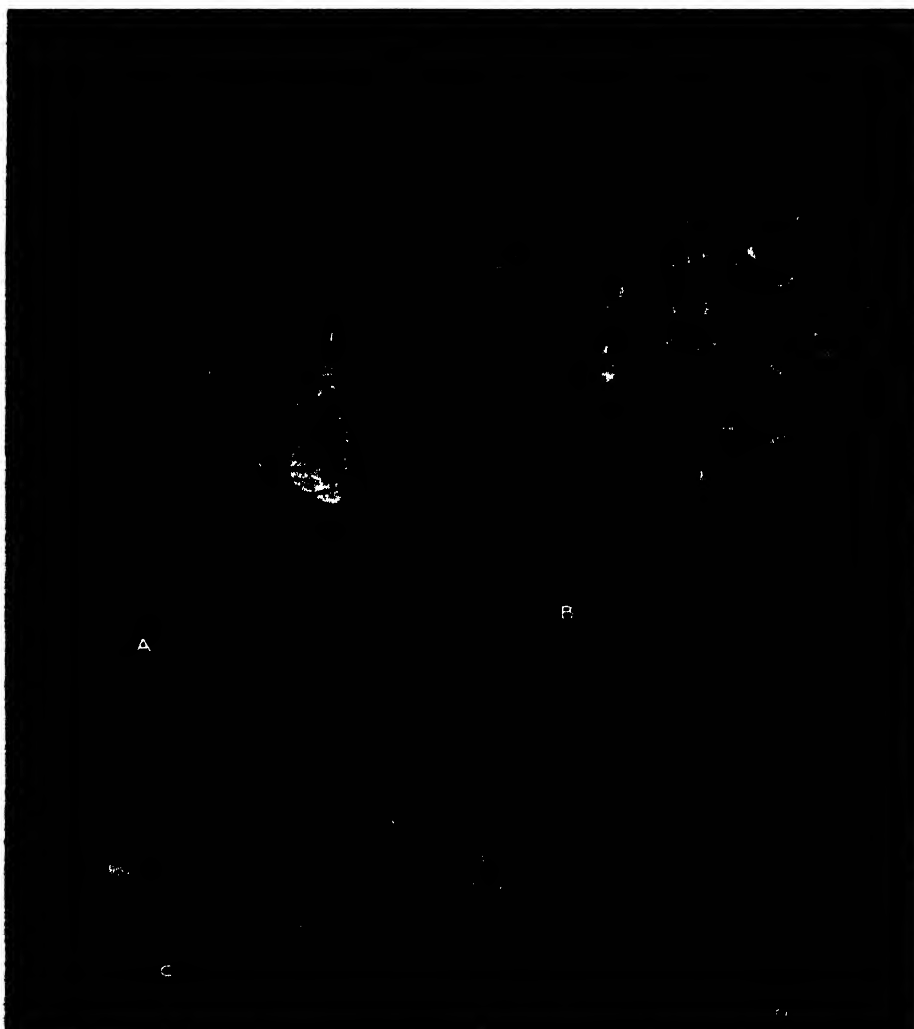


Plate 13.—*Terrapene ornata: A,* Adult, ventral view. *B,* Adult, dorsal view. *C,* Adult, lateral view. *D,* Immature individual, two and a quarter inches long.

top and sides. Each scale of the fore limbs bears a conspicuous yellow dot on a dark brown background. Tail with a pale yellow mid-dorsal line.

YOUNG.—I have been entirely unable to locate a newly hatched specimen of *Terrapene ornata,* and there is no description of the young in literature. Agassiz figures the young, but unfortunately in such a position as to make description of it impossible. It appears to have a light (yellow?) blotch on the costal scutes, and a mid-dorsal light (yellow?) vertebral stripe. The fact that the young are without a trace of a vertebral keel is mentioned by several authors.

SEX DIFFERENTIATION.—The females have short tails, the males long tails, the difference lying in the fact that the anus of the male is beyond the carapace, while in the female it is located under the edge of the carapace; the difference in length lies between the anus and the tip: this distance is less in the female than in the male. Males have the claw on the first digit of the hind foot turned abruptly forward. The males cannot be distinguished, as can those of *T. carolina carolina,* by either the depression in the center of the plastron (which does not occur in *T. ornata*) or by the color of the iris of the eye.

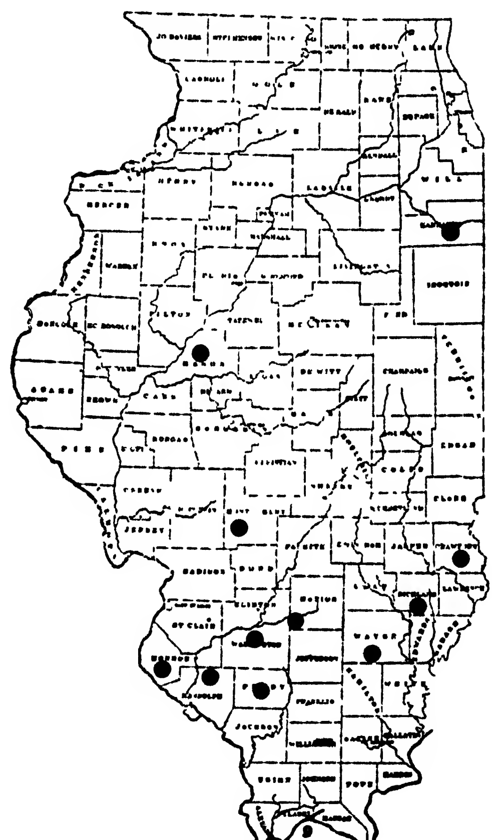
COMPARISON OF SPECIES OF TERRAPENE.—Many people seem to have considerable difficulty in distinguishing between the two species of box turtles, *T. carolina carolina* and *T. ornata,* found in Illinois. In an effort to point out the most marked differences, the following comparison is offered:

1. Carapace of *carolina* is arched, or domed.
   Carapace of *ornata* is flattened on top, or depressed.
2. Vertebral scutes of *carolina* with a median keel.
   Vertebral scutes of *ornata* without a keel.
3. Plastron of *carolina* is widest across the femorals.
   Plastron of *ornata* is widest across the abdominals.
4. Plastron of *carolina* without a bridge.
   Plastron of *ornata* with a short but distinct bridge.
5. In *carolina* the axillary element is absent or rudimentary.
   In *ornata* the axillary element is well developed.
6. Plastron of *carolina* completely closes the aperture.
   Plastron of *ornata* is a bit too short to close it completely.
7. Upper jaw of *carolina* is not notched at the tip.
   Upper jaw of *ornata* is notched at the tip.
8. In *carolina* the length of the plastron very rarely equals that of the carapace.
   In *ornata* the length of the plastron ordinarily exceeds that of the carapace.
9. When fully grown, *carolina* is a considerably larger turtle than is *ornata.*

Osteological differences:

10. Postorbital arch of *carolina* is stout.
    Postorbital arch of *ornata* is very slender.
11. Quadrato-jugal of *carolina* is present but rudimentary.
    Quadrato-jugal of *ornata* is absent.

Geographic Distribution.—According to Stejneger and Barbour (1923) the range of *Terrapene ornata* is: "Indiana, Illinois and the territory between the Missouri and Mississippi rivers and the Rocky Mountains from the Yellowstone River in the north to the Gulf of Mexico in the south, southern New Mexico, Arizona and northern Mexico." In general terms, *T. ornata* may be said to be a western form which reaches its eastern limit of distribution in eastern Illinois, while *T. carolina carolina* is an eastern form which extends westward approximately to the Mississippi River. Ellis and Henderson (1913) report it from Colorado; it is reported by various authors from Wyoming, Kansas, Oklahoma, Nebraska, Arkansas, New Mexico, and Texas. In the southern United States it does not occur east of Texas. Hurter (1911) reports it generally distributed over Missouri. Hay does not list it in either of his reports on Indiana. Evermann and Clark (1930), however, report *T. ornata* as established in the Lake Maxinkuckee region of northern Indiana since about 1923. For Wisconsin, Higley (1889) records it from Walworth County, while Hoy (1883) reports it from Grant County; Pope and Dickinson (1928) add a specimen from Columbia County, and give its range in the state as "apparently only southern Wisconsin." Blanchard (1922 reports it as very rare in Dickinson County, Iowa.



Map 9.—*Terrapene ornata.*

Illinois Records.—There are relatively few records for Illinois for this species of box turtle. Garman (1892) records it only from Fairfield, as does Hay (1892); as a matter of fact, both of these reports are the Yarrow (1882) record, U. S. National Museum #9937, 9938, 9940. Hurter (1911) reports it from Baldwin, Randolph County, and from Addieville, Washington County. Taylor (1895) had a specimen from Kankakee, and another specimen (U. S. National Museum 7542) sent in by Kennicott from "Illinois." Vestal (1913) found it in Mason

County, and Blanchard (1924) at Rosebud, Monroe County. An error occurs in the report of Gaige (1914); in this report of specimens from Richland County, *T. carolina* should read *T. ornata,* according to a personal letter from Dr. Gaige to the writer. In this county, *T. ornata* is reported to be very abundant. The writer has examined specimens from Fairfield, Centralia, Addieville, Pinkneyville, Robinson, and Litchfield; in the latter region this species of box turtle is very abundant. On November 4, 1930, a deluge of box turtles was mysteriously let loose on Michigan Avenue, Chicago. Eventually over 500 specimens were collected, consisting mostly of *Terrapene ornata,* with only a few specimens of *T. carolina triunguis* mixed in. Of these, about 500 specimens of *T. ornata* (no *triunguis*) were finally liberated by Dr. Karl P. Schmidt of the Field Museum, in the sandy area around Waukegan. Dr. Schmidt writes me under date of March 8, 1932: "Only a few of these survived the winter, and I doubt if the species 'takes.' All were marked with drill holes in the posterior rim of the shell." The fact of this planting should be noted, however, in case of the eventual appearance of the species around Waukegan. Where these turtles came from or how they got there is unknown, but it is believed that they were the chief performers in the thrilling sport of turtle racing, probably belonging to a "stable" the owner of which went broke.

HABITAT.—Whereas *Terrapene carolina carolina* is distinctly an inhabitant of the deciduous woods environment, *Terrapene ornata* is a prairie species. It is found out in the open prairies or in sandy areas, wandering among the short grasses, and is very rare indeed in association with trees or heavy ground cover. Around Litchfield, Illinois, where the species is really very common, these box turtles are picked up in the open fields and pastures. While both *T. carolina* and *T. ornata* are abundant in this region, their environmental preferences keep them remarkably apart in their distribution.

HABITS.—In general the habits of *T. ornata* are very similar to those of *T. carolina* which we have already discussed in some detail; hence we will be brief in our discussion of this species. Certain points of contrast in behavior should be considered. In our discussion of *T. carolina* we noted certain very marked tendencies toward an aquatic habit. Such tendencies seem to be entirely absent in *T. ornata.* We have seen that certain individuals of *T. carolina* took up a decided and definite home in the puddle of water at one end of the outdoor pen in which they were confined. While there were seventeen specimens of *T. ornata* in the same pen and these had the same range as *carolina,* not one was ever seen to enter the water. If one was placed in the water, it scrambled out as fast as it could and headed for the other end of the pen. One half of the pen is grown in herbaceous ground cover and bushes; the other end

is open and sandy. While *T. carolina* occasionally wandered, naturally, into the open end, the turtles of this species spent by far the greater part of their time around the "wooded" portion, and the reverse of this is equally true of *T. ornata*.

In disposition there is also quite a noticeable contrast. While *T. carolina* is of a quiet and peaceful nature, yet it will snap on occasion. I have never seen *T. ornata* exhibit any defense reaction of this sort; in fact I have never been able to provoke it to the point where it would snap. It seems to have complete and absolute control of its temper and to have developed a completely fatalistic attitude. Its movements are more rapid than those of *T. carolina*, and its rate of progression is quite a bit faster. This may well be due to its lesser bulk, for it is a smaller turtle.

I was able to compare the hibernation of these two box turtles in my outdoor pen. *T. ornata* goes into hibernation earlier than does *T. carolina*, for every specimen of this species had disappeared fully two weeks before the first of *T. carolina* showed a desire to hibernate. Once *T. ornata* has dug into the ground, it does not again emerge until spring. Like *carolina*, they start a few inches under the surface of the ground in October, and work their way deeper and deeper into the earth as the temperature of the soil drops. Whereas *T. carolina* ceases its descent at 19 inches, *T. ornata* went down to a depth of 22½ inches. This greater depth of hibernation is sufficient to account for the fact that the period of inactivity is greater, and *ornata* does not emerge until a week or two after *carolina* has thawed out and become active. Thus it remains in hibernation nearly a month longer than *carolina*.

Whether this species enters into temporary periods of aestivation or not is not clear, but there is a hint of it in a sentence by Ortenburger (1930): "In some instances they had burrowed partially into the mud of the river bank." This at least hints strongly at the very similar but perhaps more definitely developed aestivation habit of *T. carolina* during the hotter parts of the summer.

Nesting Habits and Eggs.—I have no information at hand as to the breeding habits of *T. ornata*. While the females which I placed in my outdoor pen had (as seen in the dissection of certain individuals) large eggs in the ovaries, yet I find no young turtles. Either the turtles did not lay, or else the eggs failed for some reason to hatch. Perhaps this might be due to an insufficiency of direct sunlight in the pen. One specimen dissected had hard-shelled eggs in the oviduct. Most of the specimens of *T. ornata*, however, had the large eggs for that season's laying still in the ovary at the time that all the females of *T. carolina* had hard-shelled eggs in the oviduct, indicating a somewhat later laying season. Since the rate of development in *carolina* is so slow (about three months) it is quite possible that, if the incubation period of *ornata* is

approximately the same, eggs laid in my pen may have been caught by the cool weather of the fall and hence not have hatched. It is quite certain that under normal and natural conditions, the eggs of *ornata*, laid in more open and exposed places, will receive a proportionately greater heat increment, and hence should perhaps have a shorter incubation period to compensate for their later laying habit. The average size of the six hard-shelled eggs removed from the oviduct was 35 mm by 23 mm. Data would seem to indicate that four to six eggs compose the usual clutch.

FOOD HABITS.—The stomachs of five specimens examined by me from Litchfield, Illinois, showed a purely vegetable diet. The mass of partially digested vegetable matter was beyond the possibility of identification, but no trace of insect remains or of other animal matter was discernible. On the other hand, Ortenburger (1930) has an interesting observation on the food habits of the species in Oklahoma: "These turtles feed to a considerable extent on the grasshoppers of the region. Some of the queerest sights seen were the attempts, often successful, of these supposedly slow-moving animals to catch grasshoppers. The movements are surprisingly quick and agile. On one occasion one turtle was seen to catch a large lubber grasshopper 'on the wing' by stretching the neck and literally jumping at the flying insect. Others were seen eating green caterpillars and robber flies."

ECONOMIC IMPORTANCE.—This turtle is not sufficiently abundant in the state to have any definite economic importance. Since, however, it has been shown to be an insect eater, whatever it does in this direction must be regarded by man as an asset.

TABLE 9.—MEASUREMENTS OF ILLINOIS SPECIMENS OF *Terrapene ornata*
(Measurements in millimeters; weight in grams)

Specimen No.	Carapace		Plastron			Head	Tail		Weight	Sex
	Length	Width	Length	Width	Depth		Total	A-T		
1	112	91	111	73	52	19	25	22	308	♀
2	103	85	103	66	49	18	24	22	219	♀
3	96	77	99	78	52	16	20	18	203	♀
4	96	83	98	71	48	17	32	20	202	♂
5	99	85	102	...	48	17	30	18	210	♂
6	105	89	106	68	51	19	22	17	320	♀
7	83	71	85	54	41	14	21	16	120	♀
8	109	96	110	69	58	16	25	19	295	♀
9	99	89	101	65	50	17	21	16	231	♀

GENUS GRAPTEMYS AGASSIZ

Emys (part) Duméril 1806
Clemmys (part) Wagner 1830
Terrapene (part) Bonaparte 1830
Malaclemys Gray 1844
Graptemys Agassiz 1857
Malacoclemmys Agassiz 1857

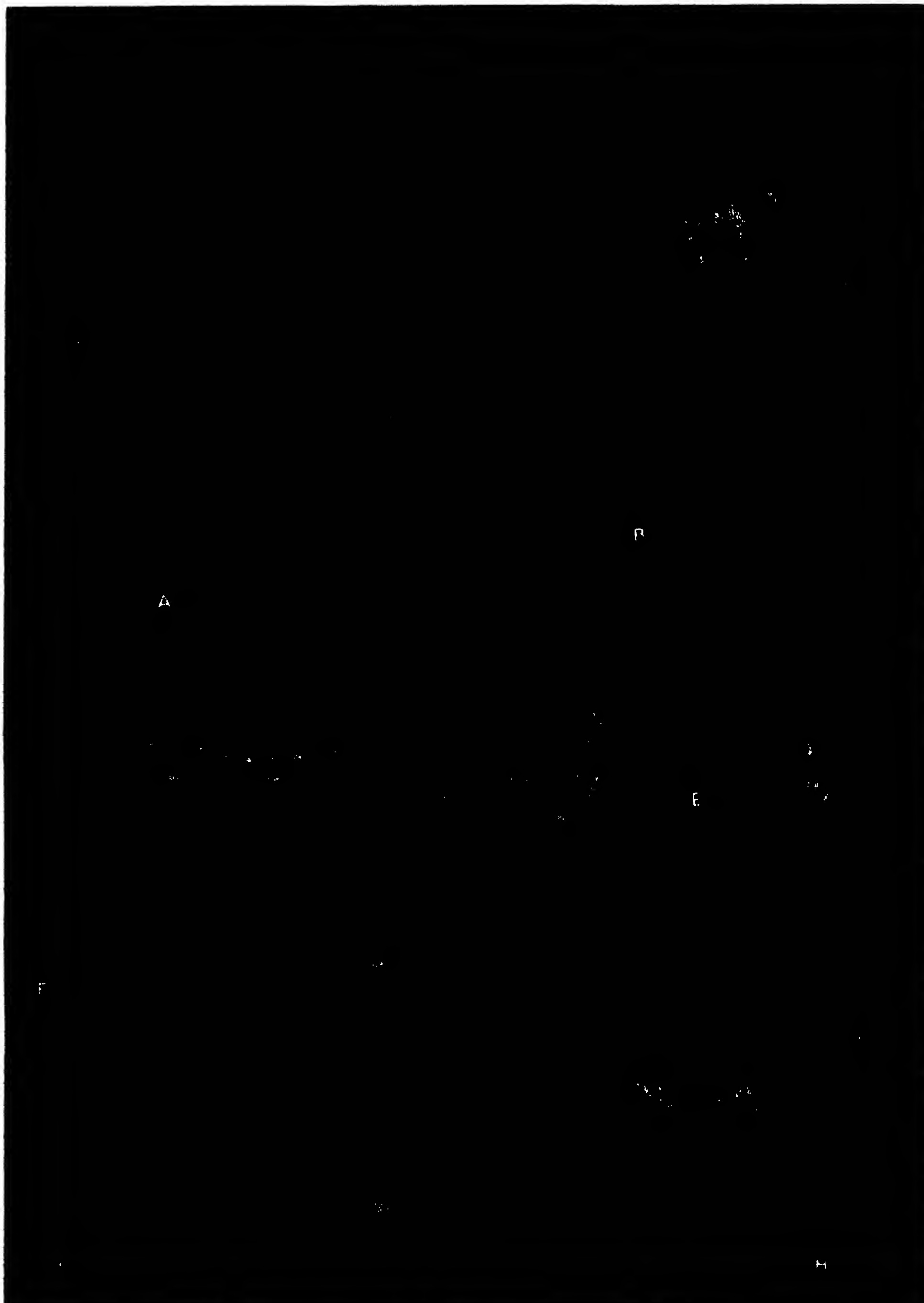


Plate 14.—*Graptemys geographica: A,* Adult female, ventral view. *B,* Adult female, dorsal view. *C,* Newly hatched young, lateral view. *D,* Newly hatched young, ventral view. *E,* Newly hatched young, dorsal view. *F,* Immature female, lateral view. *G,* Adult female, lateral view. *H,* Head study of an adult.

Shell depressed, but with a distinct and conspicuous tuberculate keel. Bridge wide, with the axillary and inguinal elements well developed; inguinal anchylosed to the fifth costal scute. Top of head covered with a tightly drawn, smooth skin. Upper jaw without a median notch. Alveolar surfaces of the jaws very wide, but without a median ridge, the right and left sides separated from each other by a deep, narrow channel. Carapace strongly serrated posteriorly. Digits fully webbed. Tail relatively short. Choanae behind the level of the eyes. Skull with a bony temporal arch. The entoplastron lies wholly anterior to the humeropectoral suture.

Graptemys geographica (LeSueur)

(Geographic turtle; map turtle; ridge-back; slider; terrapin)

Testudo geographica LeSueur 1817
Emys geographica Say 1825
Terrapene geographica Bonaparte 1830
Emys megacephala Holbrook 1844
Emys labyrinthica Duméril 1851
Graptemys geographica Agassiz 1857
Clemmys geographica Strauch 1862
Malacoclemmys geographica Cope 1875
Malacoclemmys geographicus Davis & Rice 1883

Description.—Shell oval, somewhat depressed, highest in the middle, but more elevated anteriorly than posteriorly and wider behind than in front of the middle; posterior margin serrated. Scutes of vertebral series all rather large. First vertebral weakly hexagonal, almost square, the anterior margins meeting in a wide median angle. Second and third vertebrals hexagonal, wider than long. Fourth vertebral hexagonal, the posterior margin about one-half of the anterior. Fifth vertebral pentagonal and of good size. There is a mid-dorsal vertebral keel which is persistent throughout life, but which is much more pronounced in the young and partially grown individuals than in the large adults. This keel is blunt and tends to rise to a posterior tubercle which is inconspicuous in the adult; the curvature of the keel on each scute is uniform and regularly convex in front of the tubercle. Costal scutes large. First costal roughly trapezial, large; second the largest of the series, pentagonal, the median lateral margins encroaching between the second and third vertebrals; third costal similar to the second, but smaller, not as wide; fourth the smallest of the plastral elements (excluding marginals) and approaching square. There is a tendency for the scutes, particularly the costals, to exhibit longitudinal ridges in the form of obscure roughenings; this feature is highly variable. Nuchal small, triangular, the posterior margin notched to receive the apex of the first vertebral. Marginals all large and wide, and with an even edge through the sixth. The seventh marginal increases in size posteriorly and the remaining five are notably larger than the anterior series, the eighth and ninth being the largest. Marginals serrated posteriorly from the eighth to the caudals, and there

is a conspicuous notch between these latter scutes. Posterior marginals flaring, but the caudals with a vertical tendency particularly at their median contact. The carapace is widest across the seventh and eighth marginals. Plastron large, truncate anteriorly, deeply and widely notched posteriorly. Gulars rather small, triangular, the anterior lateral angles slightly produced. Humerals trapezial, with the interhumeral suture the shortest of the mid-plastral contacts. Pectorals rectangular, the posterior lateral portion drawn out posteriorly to help form the bridge. Abdominals the largest of the series, square. Femorals the second largest of the plastral scutes, the lateral margin equalling the length of the abdominals, but the median contact shorter. Anals large, with a long interanal suture. Bridge wide, but rising only slightly toward the carapace, formed mostly by the prolongation of the abdominal and the posterior prolongation of the pectorals. Axillary and inguinal elements large. Head large and massive and with a blunt snout. Both jaws with a smooth cutting edge, the margin of the upper jaw being somewhat sinuate and *without* a median notch. Alveolar surfaces of the jaws very wide, the inner edges almost meeting, and without a median ridge. Posterior articular surface of lower jaw expanded into a spoon-like dilation. Lower jaw flat, not hooked at the tip. Limbs large, strong, with the short digits fully webbed. Hind feet very large. Five digits of fore feet with a strong claw each; four digits of the hind foot with claws, the three inner being long and somewhat curved. Fore limbs covered with a series of large, sharp-edged scales; hind limbs with scattered scales, partially on the inner surface. Tail long.

Coloration.—The coloration of *Graptemys geographica* is highly variable; not only do adults show much variability, but individuals of different ages (sizes) have conspicuously different markings. The large adult has the carapace dark olive-brown. There is a dark brown spot, almost black, at the posterior tubercle of each vertebral, and each of the costal elements is blotched irregularly with similar dark marks. There is a strong tendency toward a blotch on the sutures. Each dark blotch is encircled by a complicated pattern of pale yellow-green lines, these becoming very obscure in large specimens and increasingly conspicuous in younger individuals. Dorsally, each marginal has a dark blotch on the intermarginal suture, surrounded by the pattern of yellow-green lines. Plastron yellow, each suture lined in black. The wings of the pectorals and abdominals, together with the axillaries and inguinals, marked with black, irregular lines. The under surface of the marginals yellow, with a dark brown blotch on the intermarginal sutures, this blotch broken by enclosed irregular yellow lines. The blotches are more conspicuous and simpler from the seventh marginal backward; in front of the seventh the pattern becomes very complicated and general over the scute. Head, neck,

and limbs dark green, almost black, with lines and streaks of pale greenish-yellow. Typical head markings as follows: A conspicuous greenish-yellow, comma-shaped dash behind the eye. A straight line extends from the tip of the snout to a point behind the eye, ending abruptly. A stripe starts at the anterior median margin of the orbit as a very thin line, widening behind the eye into a conspicuous stripe which extends down the neck. Numerous other longitudinal stripes parallel this one along the neck. A conspicuous vertical stripe crosses the tympanum, then turns abruptly to extend down the neck as a ventral lateral stripe. A straight median stripe starts at the symphysis of the lower jaw and ends abruptly at a point just posterior to the angle of the jaw. Horny portion of the jaws brownish. The entire ventral surface of the neck is covered with a series of longitudinal yellow stripes that tend to parallel each other. Limbs striped, the stripes more numerous ventrally, hence the limbs darker above than below. Remaining soft parts mottled in an intricate pattern. Iris golden green.

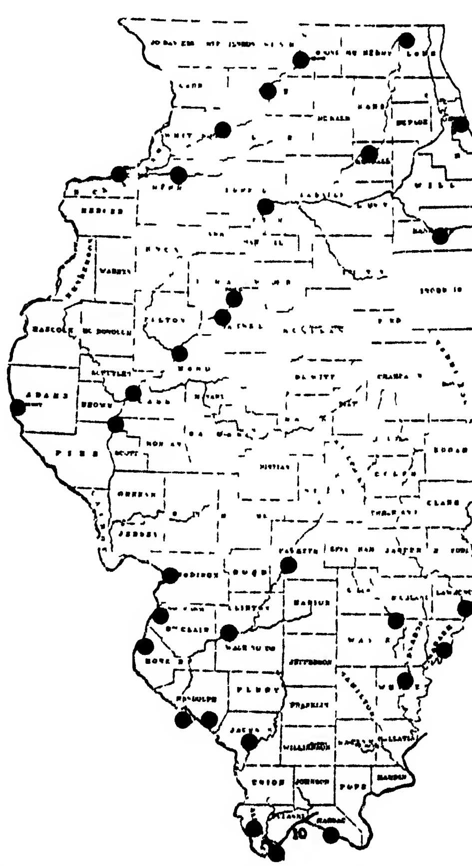
Young.—Specimen 35 mm carapace length: Carapace almost round, the length equalling the width. Shell highly arched, the posterior slope greater than the anterior. Vertebral keel prominent, particularly on the second and third vertebrals. Color dark green, with an elaborate pattern of yellow lines some of which are conspicuous and surround lines of lesser brightness. Marginals with a yellow circle at each intermarginal suture, this enclosing two (sometimes only one) yellow spots; each marginal with a vertical median yellow line and edged laterally with yellow, thus forming a yellow "T." Plastron yellow, with irregularly placed and highly variable black spots and blotches. Under side of marginals yellow, with an intermarginal black spot containing a yellow center. Color markings of head, limbs, and soft parts typical of adult.

Specimen 70 mm carapace length: The elaborate network of yellow lines on the carapace has increased in conspicuousness; ground color olive brown; markings on marginals in younger specimen. Plastral spots now becoming vague and poorly defined, blurred, fading. Keel on vertebrals prominent, tuberculate.

Specimen 140 mm carapace length: Yellow reticulations of carapace becoming weaker, while the dark brown blotches are beginning to appear; dark blotches on tubercles of the keel now well defined. Posterior serrations of marginals now deeper and very pronounced. Plastral markings practically obliterated, the dark lines along the sutures well established.

Sex Differentiation.—The head of the male is much smaller than that of the female, this character applying particularly to adults rather than to immature individuals. The tail of the male is much longer than that of the female, while the female attains a much greater total size than does the male.

GEOGRAPHIC DISTRIBUTION.—*Graptemys geographica* has a distribution encompassing most of the Mississippi Valley from Canada, Iowa, and Wisconsin southward to Oklahoma, Louisiana, and northeastern Texas. Eastward it extends through Pennsylvania to New York. Babcock (1919) finds it only along the eastern shore of Lake Champlain in New York, and notes its occurrence in Vermont. Surface (1908) gives numerous records for Pennsylvania, but points out that it is very local in its distribution. Morse (1904) says that it is common in Ohio in the larger rivers flowing into Lake Erie and into the Ohio River. In Indiana, Hay (1892) reports it generally over most of the state, and Evermann and Clark (1920) report it as by far the most abundant turtle in Lake Maxinkuckee in the northern part of that state. Ruthven *et al* (1928) report it from southern Michigan. For Wisconsin, Higley (1889) found it quite common in the southern part of the state, while Pope and Dickinson (1928) limit it to the southern and western portions of the state, but Cahn (1929) did not find it in Waukesha County of southern Wisconsin. It is probably less common in that state than formerly. Hurter (1911) records it from three widely separated points in Missouri, while Strecker and Hurter (1909) report it from Missouri and Texas, and mention its occurrence in the rivers of eastern Oklahoma. For Texas, Strecker (1915) reports it from the eastern half of the state. Patch (1925) extends the hitherto known northward range of the species into Canada with the report of specimens from Norway Bay, just west of Ottawa, Quebec, Guelph, and Point Pelee, Ontario.



MAP 10.—*Graptemys geographica.*

ILLINOIS RECORDS.—*Graptemys geographica* has a general distribution over the entire state, but is confined to the larger rivers. Yarrow (1882) records five specimens from Mt. Carmel. Davis and Rice (1883) say that it is found throughout the state, and H. Garman (1889) says that this species, together with *G. pseudogeographica*, constitutes more than half the turtles

of the Quincy region. McLain (1889) reports a specimen (1227) in the Stanford University collection from Plano, Kendall County. Garman (1892) reports it from Nippersink Lake, Green River in Henry County, Ogle County, Quincy, Peoria, Cairo, Pekin, the Little Wabash River, St. Francisville, and the Little Fox River at Phillipstown. Along the Mississippi, Hurter (1911) finds it in Madison, St. Clair, and Monroe counties. The Field Museum has a series of specimens from Havana (97, 334, 476-80, 1767, 2193) and one from Jackson Park, Chicago (2925). The writer has examined specimens from the following localities: Mt. Carmel, Chester, Peoria, Metropolis, Havana, Pekin, Meredosia, Sterling, Rock Island, Quincy, the Kankakee River at Kankakee, Bureau, Beardstown, Fox Lake, Okawville, Vandalia, Murphysboro, and Horseshoe Lake in Alexander county.

HABITAT.—An abundant turtle throughout the state, frequenting most commonly the lakes and larger rivers, this species is less often found in the smaller streams. In over-flow ponds along the courses of the rivers they often occur in large numbers, but they leave these for the rivers themselves if the ponds begin to dry up. Garman (1892) says that "half the individuals which one may see perched on logs during a day's boating in August would prove to be of this species." The present writer believes that this species is less numerous than formerly, yet distinctly more common than the next, closely related, species. These turtles prefer water in which grows an abundance of such vegetation as Chara and Nitella, and this is utilized to the utmost for concealment in time of danger and affords the hunting grounds for their food supply. They are seldom found in clear water and very rarely indeed in swift flowing streams, unless it be during temporary periods of flood or high water. Large, swift rivers, like the Mississippi and the Illinois, and especially the backwaters of these, with soft bottoms, afford an ideal environment, and in such places the species finds its optimum.

HABITS.—*Graptemys geographica* is highly aquatic in its habits. Its strongly webbed feet afford it excellent propellors, but the bulk and weight of the shell are such that it is not a fast swimmer. The hind feet are particularly large and drive the turtle at a reasonable speed. On land the turtle is slow, awkward, and evidently ill at ease. It is found on land only during the breeding season and under such unusual circumstances as may drive it from one pond or river to another. If caught on land, the head is withdrawn with a hissing sound caused by the expulsion of air from the lungs accompanying the withdrawal of the head and neck within the shell. If provoked it emits an occasional hiss as the head is withdrawn farther and farther into the protective position. Wary and cautious while in the water, on land the turtle is timid and very inoffen-

sive despite the power and strong cutting edges of the jaws. Both the structure of the jaws and the powerful musculature thereto attached would enable it to do serious damage were its disposition less retiring.

These turtles are among the earliest to make their appearance in the spring. The coldest months of the winter may be spent in the mud at the bottom of the river or in the soft banks; occasionally muskrat runways are utilized, the turtles either burying themselves in the soft floor of the passage or remaining half concealed in the runway itself. Shortly after the ice goes out they are found basking on the shore at the very edge of the water. Those which hibernate in shallow lagoons or ponds come out first, for here the water warms up earlier than in the bed of the larger rivers. At this time they are slow and sluggish and may be easily caught. They love the sunshine, and spend hour after hour lying motionless as they absorb the heat. With the first chill of later afternoon they disappear into the water, but as April wears on they remain out longer and longer. They are highly gregarious and usually found in close association with their own kind. This gregariousness makes them difficult to approach, for when one becomes frightened and slides into the water, all promptly become panic stricken and disappear likewise. During the long summer days they bask luxuriously upon logs well out in the water, lying with the hind legs outstretched. Through field glasses they may be seen snapping at passing insects, many of which they succeed in catching. With the approach of fall their basking periods are shortened, though these turtles are among the very last to go into hibernation. There is some evidence that occasional individuals do not hibernate at all, but remain slightly active on the river bottom all winter. Along the banks of the Illinois River I have found dozens of young specimens that fell victim to this disinclination to hibernate. They had remained out of water too long: numbed with the cold, they were unable to regain the water; stranded, they froze to death.

Nesting Habits.—Late in May, and from then until mid-June, the females come out to lay their eggs. Their timid disposition leads them to come out very early in the morning, for they prefer solitude, and daylight finds the turtle well on its journey. The female comes out of the water slowly but there is an air of stolid determination about her. She wanders about in a zigzag path for some time, often getting far from water in her search for the exactly suitable nesting site. The moist sand of the shoreline interests her not in the least. One may sometimes follow her tracks if the ground is suitable, and the aimlessness of her wandering is quite evident from the great irregularity of her course. Here she pauses to dig: a small rock interferes, so she goes on. Here she tries again, but a small root is in the way, so she gives it up and wanders on. Here she digs again, but some undefinable thing does not suit her—

perhaps the soil was not just right—so she goes on again. After hours of search and many efforts at digging, the right spot is found and the nest is dug. This is a symmetrical flask-shaped cavity of a diameter sufficient to admit her, dug with the hind feet only, the front feet being used as a brace. The length of the neck and the size of the flask depend upon the character of the soil selected and the number of eggs to be produced. I have seen dozens of nests of this species but never yet one that was not well filled, nor one that was over full. Once the digging has begun in earnest, the female is determined to go on with it to the end; if disturbed, she watches the intruder for a time, but does not retreat, and when things quiet down she resumes her work. The eggs are laid in a double layer in the body of the flask, often with a thin layer of dirt between the eggs. In the neck of the flask are deposited the last two or three eggs, the last egg laid being very close to the surface. The loose dirt is then scraped into and over the hole and the surface smoothed by dragging the plastron over the small area disturbed so as to erase the least trace of the disturbance.

Eggs.—The number of eggs deposited varies from ten to sixteen, depending upon the size and age of the turtle, with twelve to fourteen by far the commonest number. They are white and elliptical, with a soft, leathery shell which may be very easily indented. They average 32 mm by 21 mm. The rate of development is slow, the young hatching usually about mid-August or shortly thereafter. The young dig themselves out, coming up through that position of the ground occupied by the nest, this affording them the least resistance. Once at the surface they blink the dirt out of their eyes and head straight for the nearest water, even though it be a quarter of a mile or more away and may take a week to reach. Newman (1906) reports newly hatched young in May, and explains it in reference to unusual females found laying in late July, saying that the "well advanced embryos must pass the winter in a condition of dormancy analogous to that observed in hibernating adults." I have in my collection several newly hatched young taken in the vicinity of Meredosia on the Illinois in early July. There seems to be no reason why a well developed embryo should not live over the winter within the egg; the dropping of the temperature slows up the rate of development and the embryo remains *in status quo* until the warmth of spring penetrates to the eggs, whereupon it resumes its development. Furthermore, turtles are poikilothermous. Whether those eggs in the neck of the nest, only an inch or two beneath the surface, hatch after a thorough freezing is undetermined.

Food Habits.—The great width of the masticatory surfaces of the jaws are admirably suited for cracking mollusks, and stomach examinations show a very large percentage of these animals in the diet. Snails,

and an occasional insect or larva, are the main items of food taken. So badly crushed are molluscan remains that identification is almost impossible. Besides this fact, the hard parts of the shell are scratched out of the mouth by means of the claws of the front feet. Newman (1906) makes an interesting observation: "Two methods of feeding prevail. The favorite method seems to be to capture the mollusc when the foot and gills are well out of the shell, to bite off the soft parts and leave the hard shell. To do this the final closure of the jaws must be quite sudden. If they fail to secure the body of the snail in this way, they adopt the crushing method." I have frequently watched this species prowling slowly about amid the vegetation looking for snails, and thick beds of aquatic

TABLE 10.—MEASUREMENTS OF ILLINOIS SPECIMENS OF *Graptemys geographica*
(Measurements in millimeters; weight in grams)

Specimen No.	Carapace		Plastron			Head	Tail	Weight	Sex
	Length	Width	Length	Width	Depth				
1.......	227	170	196	103	84	33	86	...	♀
2.......	203	181	213	141	85	34	79	1687	♀
3.......	203	158	183	113	72	31	60	1055	♀
4.......	190	141	169	118	66	29	71	780	♀
5.......	186	140	168	110	63	33	68	740	♀
6.......	151	126	142	96	53	26	61	498	..
7.......	133	98	115	57	41	19	71	...	♂
8.......	118	97	106	54	42	17	40	...	♀
9.......	116	87	101	48	37	17	65	...	♂
10.......	113	86	98	47	36	16	63	...	♂
11.......	106	82	90	43	35	15	62	..	♂
12.......	70	62	61	32	27	13	22	...	♀
13.......	38	32	35	21	16	9	19	...	♂

TEXT-FIGURE 15.—Drawings of lower jaws, showing difference in alveolar surfaces. *A*—*Graptemys geographica; B*—*Graptemys pseudogeographica pseudogeographica.*

plants are often thoroughly tunneled by pathways made by these turtles in search of their food. In the laboratory they refuse every kind of food except snails and clams, showing almost a total lack of the scavenger habit so often found among turtles.

Economic Importance.—*Graptemys geographica* is caught in great numbers by net fishermen, but does not often reach the public market, probably because it seldom reaches a size sufficiently large to warrant shipment. The larger specimens, however, are excellent for the table. The flesh is entirely palatable, and except for the size there is no reason why they should not be used as food.

Graptemys pseudogeographica pseudogeographica (Gray)

(Ridge-back; map turtle; saw-back; slider; "terrapene"; river terrapin)

Emys lesueurii Gray 1831
Emys pseudogeographica Gray 1835
Emys geographica (part) Duméril & Bibron 1835
Graptemys lesueurii Agassiz 1857
Graptemys pseudogeographica Gray 1863
Clemmys pseudogeographica Strauch 1865
Malacoclemmys pseudogeographicus Cope 1875
Malacoclemmys lesueuri True (in Yarrow 1882)
Malaclemys pseudo-geographica Hay 1892
Graptemys pseudogeographicus Paulmier 1902
Graptemys pseudogeographica pseudogeographica Stejneger & Barbour 1923

Description.—Shell oval, somewhat depressed, rather flat-topped in fully grown specimens, highest in the middle, emarginate posteriorly. Carapace with a conspicuous persistent vertebral ridge rising to a prominent posterior tubercle which is well developed upon the second and third scutes. Vertebrals five, the first the smallest of the series. Second and fourth vertebral scutes of approximately the same size, hexagonal; the anterior margin of the second is shorter than the posterior and this is reversed in the fourth scute. The third is the largest of the series, hexagonal, the anterior and posterior margins about equal. The fifth vertebral is variable in form, sometimes being rather "maple-leaf"-shaped, the total length, however, about equalling the maximum width of the scute; this maximum width is attained by wing-like lateral projections which intrude deeply between the fourth and fifth costals—if a fifth is present. If but four costals are present the fifth vertebral is pentagonal and wider than long. The keel is low and inconspicuous on the first vertebral. On the second it begins to rise at about the middle of the scute and reaches a sharp posterior tubercle at the very posterior edge of the scale. On the anterior portion of the third vertebral a low ridge drops from the apex of the anterior tubercle toward the middle of the scute and rises again to a conspicuous tubercle at the posterior margin,

giving a *concave* profile to the keel which is particularly obvious on the third (and much less so on the second) vertebral scute. The number of costals shows some variation; the usual number is four, but occasionally five are present. If five, the fifth vertebral is drawn in, as described above, in order to make room for it. Costals large. First costal large,

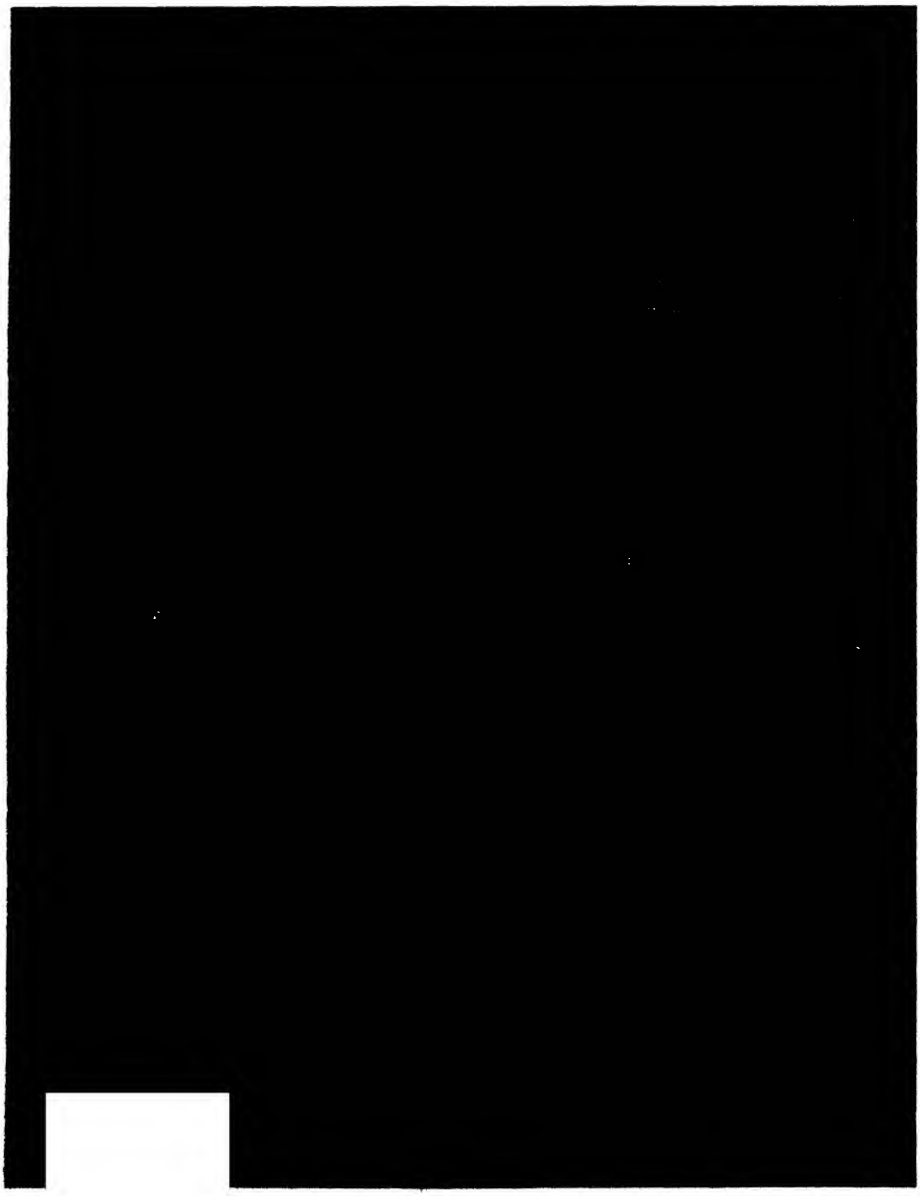


PLATE 15.—*Graptemys pseudogeographica pseudogeographica: A,* Adult, ventral view. *B,* Adult, dorsal view. *C,* Adult, lateral view. *D,* Newly hatched young, lateral view. *E,* Newly hatched young, ventral view. *F,* Newly hatched young, dorsal view. *G,* Head study of an adult.

roughly triangular. The second is the largest of the series and is wider than long; the third is of the same shape and proportions as the second, but somewhat smaller. The fourth is roughly rectangular if a fifth is present, but approaching square if only four are present. If a fifth is present it is by far the smallest of the series. Nuchal with a posterior notch to accommodate the anterior angle of the first vertebral. Thirteen pairs of marginals. First marginals with the median border much shorter than the lateral, giving the appearance of a "bow tie" to them and the enclosed nuchal. There is a slight serration associated with the first two anterior scutes. The marginals begin to flare widely at the eighth, from which point the edge of the carapace becomes increasingly more serrated posteriorly. Caudals rise sharply toward their median symphysis and contain a sharp, deep posterior notch. Plastron large and strong, the anterior and posterior lobes being of approximately the same length and width, truncate anteriorly and widely emarginate posteriorly. Gulars triangular, the length equalling the width. Humerals with the inter-humeral angle the shortest of the plastral sutures. Pectorals rectangular. Abdominals nearly square, the largest of the ventral elements. Femorals next to the abdominals in size, the lateral margin equalling the length of the abdominals but with the median contact shorter. Anals large, the interanal suture longer than the interfemoral; the anal notch is wide and generally rounded. The bridge is wide and flat, rising but little toward the carapace. Axillary and inguinal elements large and well developed. Head medium to large, depending upon the sex of the specimen; snout not protruding. The cutting edge of the upper jaw is smooth and slightly convex and without a notch; lower jaw with the cutting edge slightly convex and without a hook. Alveolar surfaces moderately wide, wholly separated in front by soft skin. The limbs are well developed, the hind limbs being particularly strong and well developed. Digits fully webbed to the base of the claws. Five digits on fore limb, each with a claw; four digits only of the hind foot with claws, the fifth lacking a claw. Tail rather short, pointed.

Coloration.—In fully adult specimens the carapace is olive green, sometimes with a brownish cast. Each costal and many of the marginals exhibit a dark brown, almost black posterior blotch; there is a tendency for each blotch to be encircled by a yellowish or greenish line. The vertebral keel is dark brown, darkest at the tubercle. Scutes of the carapace with irregular network of yellowish or greenish reticulations or tracings; these reticulations are often rather obscure in large (old) specimens. The plastron of the large adult is yellow, with a varying amount of vague, dusky discoloration which may be totally absent; younger specimens show a bilateral pattern of dark areas enclosing yellow markings within, reminding one somewhat of *Chrysemys picta*

bellii. Bridge marked with dusky, tending toward longitudinal lines. Axillaries and inguinals either lined or blotched with dusky discolorations. Marginals irregularly marked with a dusky color on the ventral surface. Head dark olive green, elaborately marked with yellow lines. Behind the eye is a conspicuous yellow transverse streak which, medially, turns posteriorly to extend down the head and neck parallel to the streak from the opposite side. On the head it has the appearance of a boomerang. Sometimes this mark is carried down below the eye. A straight yellow line extends from the tip of the snout to well behind the posterior margin of the eyes, terminating between the angles of the boomerang. Below the eye is a small yellow spot. The remaining portions of the head with fine yellow lines, many of which extend down the neck parallel to each other. Jaws mottled with yellow. There is a yellow spot at the symphysis of the lower jaw. Limbs, tail, and the remaining soft parts olive green, elaborately lined with yellow.

Young.—In very young individuals (32 mm) the shell is almost perfectly round. Carapace very high, with a steep lateral slope; anterior slope abrupt; posterior slope more gradual. Keel very conspicuous, particularly on the second and third scutes, but without any trace of the concave profile. Marginals all more or less in line with the general curvature of the carapace. Posterior marginals not only with an intermarginal notch but with a strong tendency toward a second notch in the middle of the edge of each scute, giving the border a very "saw-toothed" appearance. Color bright green, with conspicuous yellow tracings; the dark mark upon the keel of the vertebrals conspicuous. Plastron with a bilateral dusky pattern on yellow, with numerous yellow inclusions. Surface of the carapace finely granular. As the turtles grow larger the shape and pattern tend toward that of the adult. In a larger specimen (102 mm) the dark blotches on the costals and marginals are beginning to appear, the color is now brownish and the yellow tracings still conspicuous, especially about the forming dark blotches. There is still a faint trace of the toothing of the anterior marginals, but the tooth in the middle of the border is growing very weak. The concave profile of the keel is now plainly evident. Bilateral plastral markings still plain but fainter than in the newly hatched young.

Sex Differentiation.—The head of the male is relatively smaller than that of the female, which is quite massive. The tail of the male is longer than that of the female, thus extending the anus beyond the posterior margin of the carapace.

Comparison of the Two Species of Graptemys.—Although to the uninitiated there seems to be considerable difficulty in separating *Graptemys geographica* from *Graptemys pseudogeographica pseudogeographica*, there are certain differences which usually will make the distinction

less difficult. These differences have been ably discussed by Garman (1890). We may summarize them as follows:

1. *Head.*—Large, massive in *G. geographica,* contained about 4.6 times in the length of the carapace; small to medium in *G. pseudogeographica,* contained in the carapace about 6.4 times.

2. *Jaws.*—Alveolar surfaces of *G. geographica* greatly expanded, while this is not the case in *G. pseudogeographica* (see Text-fig. 15).

3. *Vertebral Ridge.*—In *G. geographica* the median vertebral ridge is obscure, flattened, and in profile a simple curve and not of the tuberculate type; in *G. pseudogeographica* this ridge is very prominent, tuberculate, and exhibiting a concave profile on at least the third scute.

4. *Spot Behind Eye.*—In *G. geographica* this spot is not comma-shaped; it is isolated and is directed longitudinally. In *G. pseudogeographica* it is comma-shaped or like a boomerang, not isolated, being continued as a fine stripe down the neck.

5. *Mandibular Spot.*—There is a yellow stripe on the symphysis of the mandible of *G. geographica,* while this mark is in the form of a yellow spot in *G. pseudogeographica.*

6. *Supraoccipital Spine.*—Though purely an osteological character, *G. geographica* has an enlarged, thickened supraoccipital spine, while *G. pseudogeographica* shows a small, unthickened spine.

Geographic Distribution.—*Graptemys pseudogeographica pseudogeographica* is distributed over the Mississippi Valley from Wisconsin and northern Iowa southward, and from eastern Kansas and Oklahoma eastward to Ohio and Alabama. Thus it is seen to have a more circumscribed range than *Graptemys geographica.* To the east of Illinois it is reported from Columbus, Ohio, by Yarrow (1882), though it is not included in the state list by Morse (1904). It is not listed by Ruthven *et al* (1928) from Michigan. Blatchley (1891) lists it from Indiana, while Hay (1892) reports it from several localities in that state. The type locality is the Wabash River at New Harmony, Indiana, which is just across the river from Illinois. In Wisconsin, Hoy (1883) reports it as not rare, while Higley (1889) says it is quite common in the southern half of the state; Cahn (1929) did not find it in Waukesha County. Pope and Dickinson (1928) refer it to the western part of Wisconsin. In Missouri, Hurter (1911) gives numerous records, while in South Dakota, Over (1923) reports it only from the Missouri River, which it no doubt ascends from the Missouri region. Yarrow (1882) gives a single record for Kansas, as does Burt (1927) for that state. In the south its place is taken by two sub-species, *G. pseudogeographica kohnii* and *G. pseudogeographica oculifera.*

Illinois Records.—For Illinois, Garman (1892) says: "Throughout the state, but less common north," and gives records from Quincy, Jersey County, the Wabash Valley, the Ohio River, and Cairo. In his paper dealing with the Quincy region (1888) he says that the two species

of Graptemys constitute about half the turtles seen, while in his short notes (1892) he reports it as "very abundant in all our rivers." It is not mentioned by Hankinson (1917) for the Charleston region, while Davis and Rice (1883) say that it is found in all parts of the state. With the records mapped, it appears that Garman's statement of 1892 is nearest correct at the present time. The Field Museum has specimens from Havana (#95, 331, 475, 1759, 1773), McHenry (#2670), and Maeys (#3464, 3465). Hurter (1911) reports it from Madison, St. Clair, Monroe, and Randolph counties. The writer has examined specimens from the following places: Chester, Havana, Meredosia, Quincy, Grafton, Carlyle, Okawville, Murphysboro, Metropolis, Mt. Carmel, Elizabethtown, Horseshoe Lake in Alexander County, and Carmi, which is only a few miles from the type locality.

MAP 11.—*Graptemys pseudogeographica pseudogeographica.*

HABITAT.—This abundant turtle within the state is distinctly of aquatic habits; indeed, so strictly does it remain in the water that it is usually referred to in the literature as "eminently aquatic." It is found in lakes, ponds, sloughs, and larger rivers, and is about equally abundant in all of these types of habitats. It is more common in waters abundant in bottom vegetation among which the turtles delight in wandering, and distinctly less common in the clearer waters. It is absent from lakes lacking this dense vegetation, or at least from those regions of the lake in which the vegetation is absent, and is not found with any frequency in rivers with any considerable current. This environmental preference perhaps explains in part the distinctly southern distribution of the species in Illinois, for in the southern portion of the state these aquatic conditions, congenial to *G. pseudogeographica,* are of more frequent occurrence. It would appear, also, that the species is more delicately attuned in its environmental preferences than the preceding species, for it is less hardy and distinctly shorter lived under adverse conditions.

HABITS.—The entire structural make-up of this turtle seems to emphasize its highly aquatic nature. The feet, especially the hind feet, are large and powerful, and the toes are fully webbed, making excellent structures of propulsion. The shell is large and relatively quite heavy, making the turtle rather awkward when out of its preferred element. In the water it is wary and secretive, disappearing from view at the least sign of danger, and remaining beneath the surface amid the protection of the dense vegetation for a long period before reappearing. These turtles are very gregarious and are often seen basking lazily in the hot sun. Basking places well away from the shore are best liked, and a protruding dead-head or a stranded log is ideal from their point of view. If such a site is not available, they will line up on half submerged logs along the shore, but under such conditions the turtles are more than ordinarily wary and on the alert, seeming to sense the added dangers which proximity to the shore brings. At the least sign of disturbance every turtle slides into the water, and this characteristic action has given to them the local name of "sliders." If caught on shore they behave much as do the turtles of the preceding species, withdrawing within their bulky shell and remaining stubbornly retracted. After having poked around for a few minutes at one I once caught on shore, I left it high and dry on the bank; returning about an hour later, the turtle was still in the same spot and had only reached the stage of renewed hope which permitted it to have its legs relaxed and its nose out about half an inch.

In the northern part of the state this species goes into hibernation during October and remains inactive until after the ice has gone out. The turtles bury themselves to a depth of from four inches to a foot or more in the soft mud of the bottom, or crawl into the under-water entrances of muskrat houses and there bury themselves. In the southern part of the state the turtles do not go into hibernation at all, but remain active, though but sluggishly so, throughout the coldest months of the winter. There is a hint that during this time they do not feed, or at least feed sparingly, for such turtles taken in the winter have invariably had the stomach empty. With the warming of the water in the spring, the turtles, as *G. geographica,* come out and sun themselves during the brightest hours of the day. The first chill of the afternoon sends them back into the water, yet occasionally an individual is found in which the reaction time to the change in temperature was too slow to get it back into the protection of the water before paralyzed by the cold. Such an individual seems always to die with one night's exposure. Such incidents are perhaps more common prior to hibernation in the fall than in the spring following it, though both have been observed.

NESTING HABITS.—The literature is strangely silent regarding the breeding habits of this turtle, the frequently cited reference being to

Agassiz (1857): "The time of the year at which they [turtles] lay is the same for both the northern and the southern species, without reference to physical differences, such as temperature, moisture, etc., of climate in general. Graptemys LeSueurii [*G. pseudogeographica*], which lays as early as the first of June, gives the earliest instance of incubation in the year." The standard reference to laying on June 1 at Natchez, Mississippi, follows as the stock example. This statement, widely quoted as it is, seems hardly to hold as a set rule; certainly it does not hold for the observations made at Meredosia in the summer of 1931. At that time, with many turtles of other species laying throughout June, it was not until July 6 that *G. pseudogeographica* began to lay. From June 13 on, females of the species with eggs mature but without the shell were found, but not a trace of evidence exists that the species laid prior to the July date. On July 6, then, a female with a carapace length of 218 mm was watched during her nesting progress. From the field notes I read: "The nesting site was in the middle of an old road, between the ruts made by the wagon wheels. The road runs about thirty feet from the river on one side and along a ditch about twenty feet away on the other. The soil is black and fairly solid. The turtle had a heavy growth of algae on her shell, and may well have come out of the ditch which is full of algae. She had apparently started digging but a few minutes before, judging from the rapidity with which the rest of the nest was dug. During the observed digging of the nest, which lasted five minutes (probably not over ten minutes was required for the entire excavation) the turtle worked with great rapidity, standing in one position. The hole was dug with the hind feet only, by scratching vigorously with legs alternating. As soon as a little pile of loose dirt accumulated, she pushed it out behind her, using both legs together to shove it out of the hole, the dirt coming in contact with the soles of the feet. The hole descended forward at an angle of 60° under her position, the sloping floor of the hole being the inclined plane up which she pushed the loose dirt. As she started to lay she slowly rotated her position to the right, pausing periodically to lay an egg or two, after which she rotated again. With all the eggs laid she was back almost where she started from, having rotated through about 350°. From this position, then, she reached back with one hind leg after the other and, using the anterior (top) of the feet, she raked the loose dirt piled immediately behind her into the hole and filled it completely. For a few moments she patted the dirt down with the soles of her hind feet, then headed back toward the ditch, and was captured. The actual time occupied in laying, as represented by the rotation through 350°, was just seven minutes. The hole was then carefully opened. The nest was 5½ inches deep, with a 2-inch opening at the

surface, and terminated in a rounded chamber at the bottom 3 inches in diameter. It contained eleven eggs."

EGGS.—The number of eggs laid varies from seven to thirteen, with nine or ten being the most common number. They are white, elliptical in shape, and covered with a soft, leathery shell of fine texture. The eleven eggs laid by the female whose nesting has been described above, measured as follows (in millimeters): 30 x 20, 32 x 21, 30 x 21, 32 x 20, 33 x 23, 33 x 21, 33 x 22, 31 x 21, 34 x 23, 29 x 20, 32 x 20. This set averages a trifle smaller than other sets on hand; the average of 71 eggs representing 7 complete egg complements, is 32.7 x 22.5 mm. I have no information in regard to the incubation period, but young of the species, certainly not very long out of the egg, have been taken in late August and early September.

FOOD HABITS.—Unlike many other species of turtles, *G. pseudogeographica* is almost exclusively a vegetarian when adult, therein showing a very striking difference when compared with the closely related *G. geographica.* The young turtles are both carnivorous and herbivorous in habits, but when they reach a carapace length of 120-130 mm, the carnivorous tendencies diminish and soon disappear. The young feed largely if not exclusively upon small mollusks, principally thin-shelled gastropods, with an occasional worm or insect larva thrown in. Stomach examinations of ten adult specimens showed quantities of chewed-up aquatic grasses, succulent stems and bulbous roots, with no trace whatever of animal matter. The bulbs of a sedge have been frequently identified. As has been noted, *G. geographica* is largely a mollusk eater, and although both species show similar habitat preferences and are found often in close association, the masticatory apparatus of the two species clearly indicates their divergent gastronomic preferences. The alveolar surfaces of *G. pseudogeographica* are not expanded or especially adapted for the crushing of mollusks, and the turtles attempt no such action except when young and then only upon small "paper-shelled" species. The species is not scavenger. Surface (1908) says, "little is known concerning the food and feeding habits of this turtle, excepting that it is said to feed upon very small fish, reptiles, etc." The writer has no evidence that would bear out this surmise. Although dozens of specimens have been kept alive in the laboratory, they would never touch meat of any kind in any form, but ate lettuce and greens sparingly. They fed only when submerged and could never be induced to eat while out of water.

ECONOMIC IMPORTANCE.—Along the Illinois River, the chief source of turtles that "go to market" from the state, the most prized and sought for species are the snapper and the soft-shells, because of their large

size. Next to these follows *G. pseudogeographica*, with *Pseudemys elegans* fourth. The fact that these turtles reach a reasonably large size when compared to other species of "terrapins" explains its presence in the turtle markets. Clark and Southall (1920) say: "the terrapin [*G. pseudogeographica*] were used as a substitute, or partial substitute, for the diamond-backs, and that for this purpose the males were not desired. What was wanted was the egg-bearing or 'queen' terrapin. . . . . During the summer of 1918 'queen' terrapin were being quoted at that place [the Illinois River] at $1 each." They reach a weight of from two to three pounds frequently, and are exceedingly good for eating.

TABLE 11.—MEASUREMENTS OF ILLINOIS SPECIMENS OF *Graptemys pseudogeographica pseudogeographica*
(Measurements in millimeters; weight in grams)

Specimen No.	Carapace		Plastron			Head	Tail	Weight	Sex
	Length	Width	Length	Width	Depth				
1.......	220	163	198	93	76	28	70	1721	♀
2.......	203	152	185	85	65	31	69	1119	♂
3.......	195	149	181	83	63	27	55	984	♀
4.......	192	148	179	85	66	29	71	968	..
5.......	185	153	179	80	67	28	50	788	♂
6.......	178	135	170	72	69	25	50	540	♀
7.......	116	86	101	63	38	17	65	158	♂
8.......	101	84	94	63	39	17	61	127	♂
9.......	95	75	82	56	34	16	30	103	♂
10.......	92	72	80	53	32	14	52	95	♂

GENUS CHRYSEMYS GRAY

Emys (part) Duméril 1806
Terrapene (part) Bonaparte 1830
Chrysemys Gray 1844
Clemmys (part) Wagler 1862

Alveolar surface of the jaws narrow, but slightly wider posteriorly; median ridge inconspicuous and the alveolar groove poorly defined in the anterior part of the jaw. Upper jaw with a median notch, lateral to which is a small tooth-like projection; lower jaw with a small tooth-like projection which fits into the upper median notch. Shell wide, much depressed; usually smooth, but in some cases with concentric rugae; no keel is present. Toes strong and fully webbed; hind feet large, spreading; claws strong, curved. Carapace and plastron united by a suture and supported by a strongly developed axillary and inguinal element; inguinal united to the fifth costal plate. Entoplastron anterior to the humero-pectoral suture. Skull with a well developed temporal arch; choanae between the eyes. Dorsal surface of the head covered with plain, tightly drawn skin.

The Chrysemys Problem

From the point of view of the genus Chrysemys, Illinois is a region of great interest and still greater complexity because of the overlapping of the range of the several subspecies. *Chrysemys picta* was described by Schneider in 1783, and was characterized by the transverse arrangement of the costal and vertebral scutes plus the clear yellow plastron. In 1831 Gray described *Chrysemys bellii,* characterized, as are all the members of the group other than *picta,* by the alternate arrangement of costals and vertebrals, and by the great development of the dark area of the plastron. In 1857 Agassiz described *Chrysemys marginata,* characterized by the greatly restricted dark area of the plastron, and *Chrysemys dorsalis,* with an immaculate yellow plastron and a conspicuous median dorsal red stripe down the vertebrals. The last of the genus to be described is *Chrysemys treleasei,* which Hurter described in 1911, distinguished from the other species by the red color of the plastron. Subsequently *bellii, dorsalis,* and *treleasei* were reduced to subspecies of *marginata, Chrysemys picta* remaining the second species of the genus. In their review of the genus Chrysemys, Bishop and Schmidt in 1931 established what they term the "intergradation" of *Chrysemys picta* of the Atlantic states with what was designated as *Chrysemys marginata marginata* whose range extended from New York to the Mississippi. Babcock (1933) points out the eastern extension of the intergrading of *Chrysemys picta marginata* with *C. p. picta* "through New England to the Atlantic coast." He gives intergrade records from Massachusetts (including Pasque Isle and Nantucket), Vermont, New Hampshire, and Maine. Since *picta* is the older name, the eastern species becomes *Chrysemys picta picta,* and the original *marginata* now becomes *picta marginata* because of these intermediate forms. Stejneger and Barbour, however, do not accept this in their 1933 revision of their *Check List;* nevertheless, the present writer proposes to follow them in their terminology. Bishop and Schmidt show the intergradation of the aligned vertebral and costal scutes of *picta picta* to the alternate arrangement found in *picta marginata,* as well as the development of the plastral markings. These writers also call attention to the intermediate conditions found in the Chrysemys from northern and central Illinois, where the subspecies *marginata* and *bellii* overlap, and mention a possible intergradation of these with *picta dorsalis* "somewhere to the south of the Ohio River."

Before discussing the Chrysemys problem in Illinois it is well to eliminate those forms which do not occur within the state. Garman (1892) includes *Chrysemys picta picta* in his list of Illinois turtles, stating that it is "very rare, if it occurs at all." It can be quite definitely stated at this time that this form does *not* occur in the state, and in the

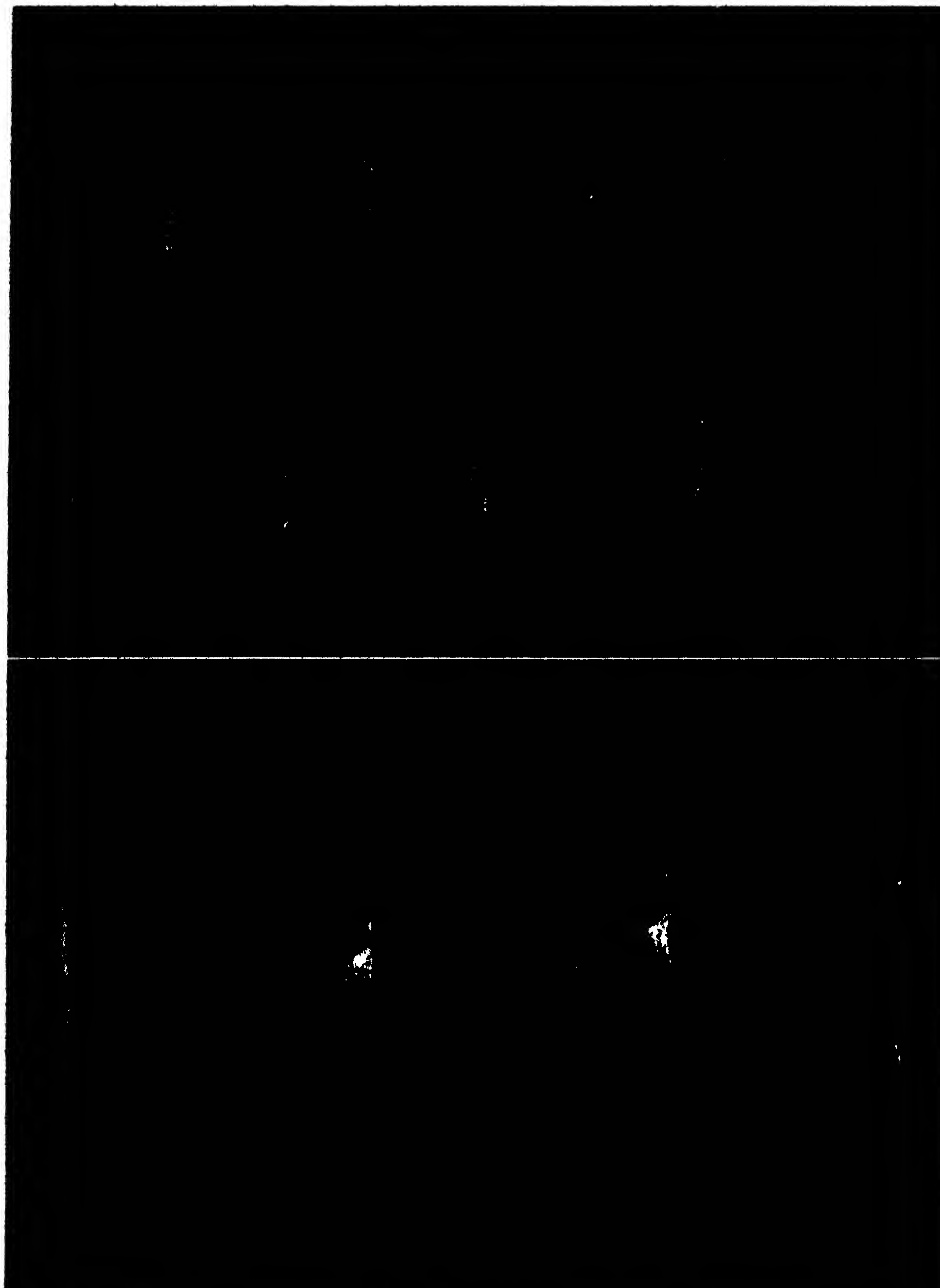


PLATE 16.—The Chrysemys Problem: (*Above*)—A series of plastra of *Chrysemys picta dorsalis,* taken at Horseshoe Lake and vicinity, arranged to show variations in markings. The upper left specimen is typical of *dorsalis.* (*Below*)—Plastra of Chrysemys taken in one drag of a net at Meredosia on the Illinois River. The left-hand specimen is typical of *marginata;* the right-hand specimen is typical of *bellii;* the middle specimen is intermediate between the two.

present paper it is dropped from the state list. As to *Chrysemys marginata treleasei* of Hurter, Bishop and Schmidt have shown that the red coloring of the plastron is due to a superficial deposit of red pigment, presumably an iron oxide, that similar deposits are to be found on other turtles of the same genus, and that there is no correlation whatever between the presence of the red color and the geographic range of the turtles. They therefore reduce the original *treleasei* to synonomy with *Chrysemys picta bellii* because of the approach to the typical *bellii* in all matters other than the red coloring of the plastron which, being a superficial deposit, has no bearing on the case. Thus we find three subspecies of the genus Chrysemys occurring in Illinois: *Chrysemys picta marginata, Chrysemys picta bellii,* and *Chrysemys picta dorsalis.* The latter is reported in this paper for the first time in the state.

Chrysemys picta marginata is an eastern form, extending from eastern New York westward through Indiana into eastern Illinois. *Chrysemys picta bellii* is a western form whose range extends from the Rocky Mountains to western Illinois. In Illinois, therefore, the ranges of these two turtles meet and overlap, and over a great part of the state an intermediate form is found coincident with the overlap. In Indiana, typical *marginata* is found; in eastern Illinois typical *marginata* is also found, but along with it are found a number of turtles in which the narrow dark plastral area shows a tendency to enlarge and creep out along the sutures, especially along the femoro-anal and gulo-humeral unions. In central Illinois, particularly in the region of the Illinois River, this tendency for the plastral mark to enlarge and spread increases, and the size of that area becomes larger, tending toward the *bellii* characteristic. In a series of 212 turtles of the genus Chrysemys taken at Meredosia on the Illinois River, 12 specimens were typical *marginata,* 33 were typical *bellii,* and the remaining 170 were intermediate between the two, extending through every degree and variation of plastral markings. Of this 170, 32 were more similar to *marginata* than to *bellii,* 46 were more similar to *bellii* than to *marginata,* and the remaining 92 showed such intermediate markings that it would be difficult to say which of the two forms they resembled unless one became arbitrary in the matter. These intermediate forms are what Bishop and Schmidt call "intergrades."

Chrysemys picta dorsalis is a southern form, extending westward into Louisiana, Arkansas, and Texas, and northward into the extreme southern tip of Illinois. Thus it is seen that somewhere in the southwest the ranges of *dorsalis* and *bellii* meet, while the ranges of *dorsalis* and *marginata* meet, almost as indicated by Bishop and Schmidt, "somewhere to the south of the Ohio River." From Cairo and Metropolis the writer has collected typical specimens of *dorsalis,* with the very characteristic

dorsal band and the immaculate plastron. He has also collected from southern Illinois and from the extreme western tip of Kentucky and northwestern Tennessee a full and complete set of forms entirely intermediate between *dorsalis* and *bellii*, both as to the development of the vertebral band and the development of the dark area on the plastron, with typical *dorsalis* and typical *bellii* at opposite ends of the series, and with *marginata* in the middle. (This series is shown in Pl. 16.) The question is, then: What are we going to do with these intermediate forms? What are we going to call them?

If the plastral markings of *marginata* and *bellii*, and the lack of plastral markings of *dorsalis*, are definite genetic characters—as they appear to be since they are practically constant and consistent over the great range of the forms, then, where the ranges of the two subspecies meet and overlap, the intermediate forms found there may well be considered as *hybrids* between them, hybrids showing incomplete dominance. This is on the understanding of a hybrid as being a cross between two distinct species or subspecies, or between individuals having distinctive differences, and without reference to any question of fecundity. In the eastern part of the country we find only *marginata;* in the western part only *bellii*. Where the ranges of these two overlap (Illinois) we find the hybrids, plus occasional typical examples of each, and we find the hybrids in far greater abundance than either of the parent stocks. The same is true where the range of southern *dorsalis* overlaps that of *bellii* and *marginata*. Since there is no physical barrier of any kind between *marginata* and *bellii*, or between *dorsalis* and either *marginata* or *bellii* in the area in which the hybrid forms occur, and since every possible variation exists between the typical parent forms within this area, it is not to be supposed that the hybrids comprise an additional subspecies.

Since the primary distinction between *marginata* and *bellii* lies in the size and distribution of the dark plastral area, it is perhaps well to delineate as definitely as possible between the two subspecies. Bishop and Schmidt (1931) have reduced this matter to a mathematical basis comparing the maximum width of the dark plastral figure to the width of the plastron as measured from the lateral margins of the abdominals where they meet the marginals in the bridge:

Chrysemys picta marginata:

Dark area occupies from 13 per cent to 67 per cent of the plastral width. Average: 36 per cent. (7 specimens out of 51 exceed 50 per cent.)

Chrysemys picta bellii:

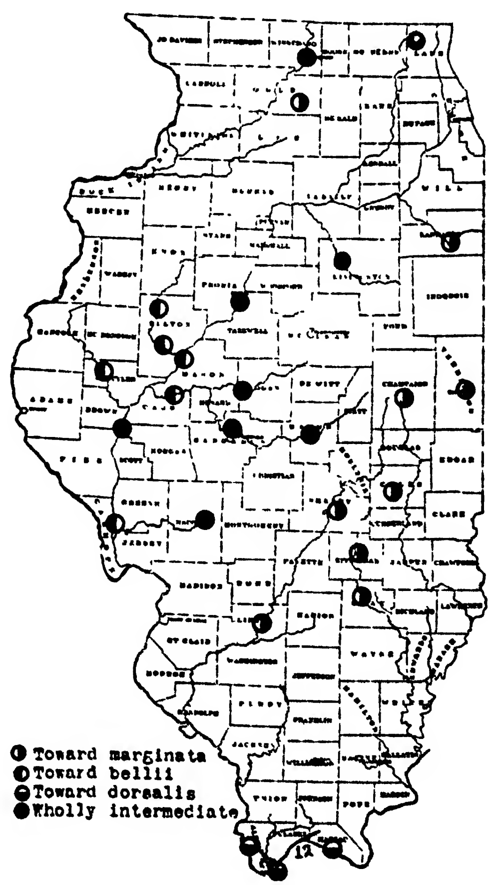
Dark area occupies from 56 per cent to 85 per cent of the plastral width. Average: 74 per cent. (5 specimens out of 44 fall below 70 per cent.)

Chrysemys intergrades:

Dark area occupies from 15 per cent to 78 per cent of the plastral width. Average: 55 per cent.

From the above figures it is seen that the hybrids extend through almost the entire range from minimum *marginata* to maximum *bellii*. The writer has checked these figures on something over 600 turtles of the genus from within Illinois, and is quite in agreement with Bishop and Schmidt. Certain points, however, have been brought out by his study.

Since Bishop and Schmidt have shown that out of 51 specimens of *marginata* only 7 exceeded 50 per cent, and out of 44 *bellii* only 5 fall below 70 per cent, I have quite arbitrarily taken 60 per cent (instead of their 55 per cent) as the dividing line, and say that any turtles between 50 per cent and 60 per cent show "*marginata* tendencies," while any between 70 per cent and 60 per cent show "*bellii* tendencies." Otherwise, since the intergradation is so complete and is illustrated by such a great assortment of percentages, it would be quite impossible to designate which way the hybrids are tending. While I have taken typical *marginata* from many localities in southeastern Illinois, this form does not extend its range far into the state before the hybrid forms begin to appear, and these fall into the group showing definite *marginata* tendencies. Such hybrids from the upper Embarrass, the Little Wabash, and the Upper Kaskaskia average 58 per cent. On the other hand, turtles from the lower Illinois River and its tributaries show the *bellii* tendencies, averaging 66 per cent. There is a third series of localities, as the lower Sangamon and certain regions on the upper Illinois River, where the variation covers almost the entire range of the hybrid scale and one cannot definitely state which way the hybrids are tending: they are wholly intermediate. The accompanying map illustrates the distribution of hybrid Chrysemys according to their "tendencies" in localities where twenty or more specimens were available for study. From this map one will note that apparently the drainage basin of the Illinois River and its



MAP 12.—Intermediate Chrysemys.

major tributaries is the zone of maximum transition between these two subspecies. While typical *Chrysemys picta dorsalis* has been taken in the extreme southern tip of Illinois, it is distinctly rare, and is associated with transition hybrid forms tending toward the *marginata* type. Similar specimens showing *dorsalis* tendencies have been taken southward to and including Reelfoot Lake, Tennessee, where, however, typical *dorsalis* is the abundant and dominant form found.

The facts of the Chrysemys problem line up as follows: (1) The most striking difference between the three subspecies occurring in Illinois is the plastral marking. (2) In one part of the country we find one expression of plastral markings (*marginata*); in another part a second expression (*bellii*); in a third part still another expression (*dorsalis*). In these areas the turtles breed typical expressions of the character. (3) Where these areas overlap (Illinois) we find turtles in which the character is expressed through a series of variations which show tendencies toward one or the other of the typical character expressions, or else so intermediate between the two as to give no indication as to which of the parent expressions they tend toward. (4) In these areas of overlapping, the number of individuals which exhibit the typical expression of the character concerned is far less than the number of the individuals showing variations or intergradations.

It seems to the present writer that there are two possible explanations that might be offered to account for these facts. Both of these are offered herewith merely tentatively, for the writer realizes fully that the only way in which the truth of the matter can eventually be ascertained is by careful and prolonged breeding experiments, a series which would require years to complete, and which he is in no position to undertake. (1) We are dealing with three distinct subspecies, *marginata, bellii,* and *dorsalis,* each being a separate form. Where the ranges of these touch and overlap, we have a hybridization between those whose ranges join, with all sorts of variations resulting. This would be termed "interspecific hybridization." (2) We are dealing with but one single species or subspecies, in which we have three expressions of *genetic* characters. This might well be called "intraspecific hybridization."

This latter idea has not yet been expressed, so far as the writer knows, and a word further might be in order. If the plastral markings of the three typical subspecies are the result of the expression of different genetic complexes, the following facts would be true: (1) Within the limits of distribution of each subspecies, each subspecies would breed true. (2) Where the limits join or overlap we have a series of expressions which differ from either parent and do not resemble either exactly, which may show a *tendency* to resemble one of the parents. (3) The number of individuals showing the expression of variation between the

two parents will far outnumber those individuals which exactly resemble the parents. These facts (2 and 3) are illustrated in the area in which hybridization occurs. If *marginata* and *bellii* and *dorsalis* are pure lines, where these pure lines come together in the overlapping range of what we are calling the typical subspecies, we would expect *quantitative variation* between the pure lines. On the surface, at least, this seems to be true.

Chrysemys picta marginata (Agassiz)

(Painted turtle; red-legged turtle; mud turtle; pond turtle)

Testudo cinerea Bonnaterre 1789
Emys cinerea Schweigger 1814
Emys picta Gravenhorst 1829
Chrysemys picta (var. 2) Gray 1855
Chrysemys marginata Agassiz 1857
Clemmys picta (var. 2) Strauch 1865
Chrysemys pulchra (part) Gray 1873
Chrysemys cinerea Boulenger 1889
Chrysemys marginata marginata Stejneger & Barbour 1923
Chrysemys bellii marginata Ruthven 1924
Chrysemys picta bellii Bishop and Schmidt 1931

DESCRIPTION.—Shell wide, depressed, broadest at about the eighth marginal scute; rather uniformly convex, highest in the middle. The posterior lateral marginals flaring. Surface smooth for the most part, but sometimes with weak concentric rugae near the lateral margins of the costal scutes and extending to the median margins of the contiguous marginals; unkeeled even in the young individuals. Vertebral scutes wider than long, and about equal to the costals in width. The anterior margin of the first vertebral greatly exceeding the posterior margin. Second, third, and fourth vertebrals hexagonal, the anterior and posterior margins of the second and third being approximately equal, while the anterior margin of the fourth is greater than its posterior margin. The fifth vertebral is somewhat the smallest of the series and tends to be pentagonal; in some specimens it shows a tendency to divide along the mid-dorsal line. The vertebrals alternate with the costals. Costal scutes somewhat larger than the vertebrals. The first costal is trapezoidal, its maximum length and width being about equal. Second and third costals wider than long, the second being a trifle wider than the third but having nearly the same length. The fourth costal is the smallest of this series, and approaches a square in shape. The nuchal is long, narrow, and with a definite median notch anteriorly; this may or may not be bordered on each side by a series of serrations extending on to the adjacent marginals, and these serrations may be very small or highly conspicuous. The marginals number 24. Posteriorly the marginals begin to flare at about the seventh scute, and there is a slight caudal notch. The plastron is broad and flat, truncate anteriorly and posteriorly. Gulars finely serrated along the anterior margin and with the anterior lateral angle prolonged into a blunt "tooth." Interhumeral and interfemoral sutures usu-

ally about equal, and both a trifle shorter than the interpectoral suture. Pectoral scutes transverse, about half the length of the abdominals. Interanal suture about equalling the interabdominal suture. The bridge is wide, rising rapidly to the marginals. The inguinal is larger than the axillary element, and both are triangular. The head is moderate in size, and distinctly flattened dorsally. Upper jaw with a distinct median notch

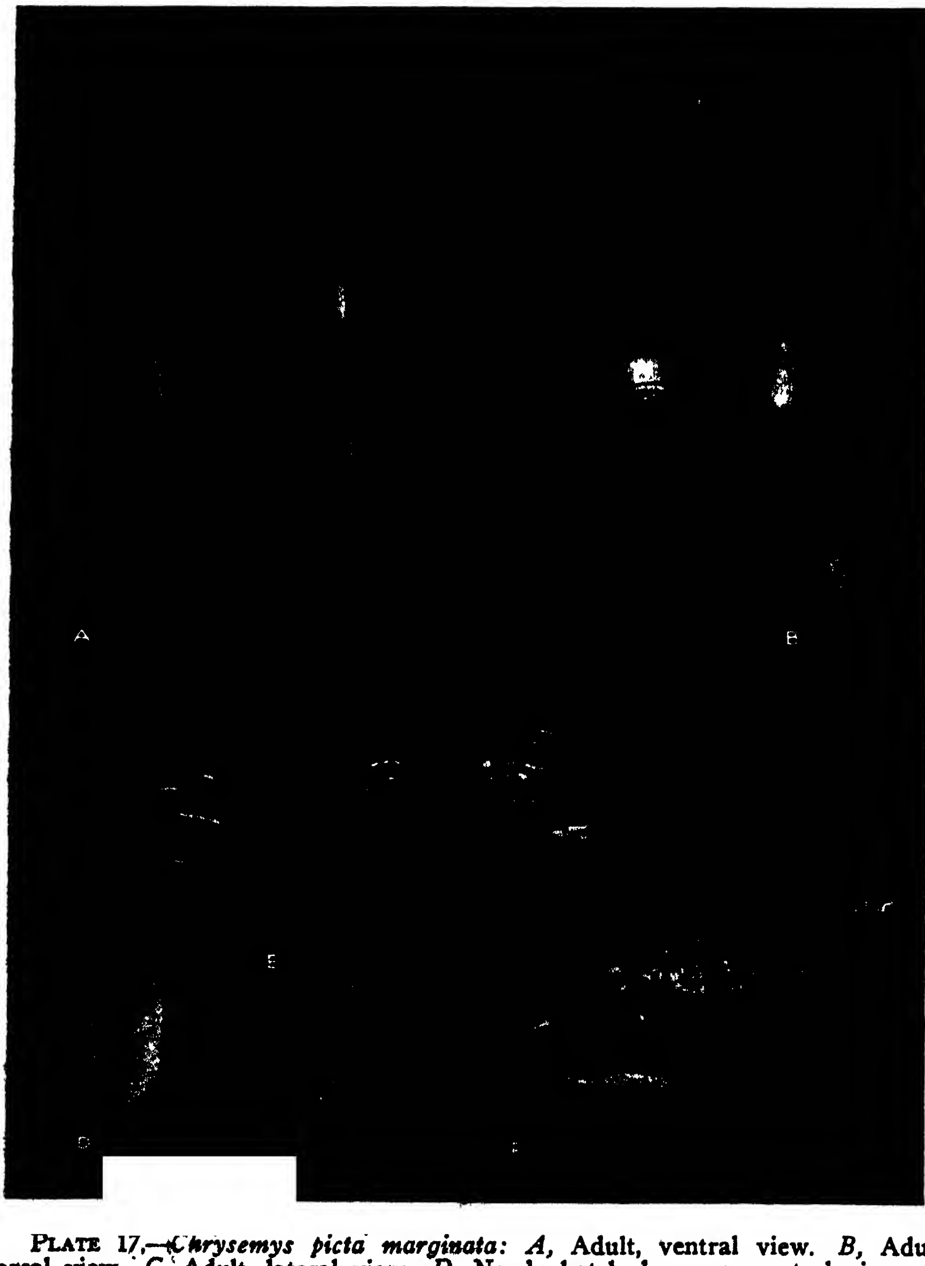


PLATE 17.—*Chrysemys picta marginata: A,* Adult, ventral view. *B,* Adult, dorsal view. *C,* Adult, lateral view. *D,* Newly hatched young, ventral view. *E,* Newly hatched young, dorsal view. *F.* Head study of an adult.

which is bordered on each side by a distinct "tooth." Snout short, not projecting far; nostrils anterior, terminal, and close together. Alveolar ridge weak. Lower jaw but little upturned and with a small median tooth. Limbs well developed, the posterior the larger. Anterior limbs with rows of transverse imbricated scales; digits 5, claws 5, these being strong and curved. Hind limbs flattened and expanded; digits 5, claws 4, the fifth toe represented by a tough marginal projection and without a claw. Claws on the hind limbs shorter than on the fore. Hind feet large. All digits fully webbed to the base of the claws.

COLORATION.—The general plan of the color pattern of *Chrysemys picta marginata* is quite stable, but the fine details prove to be highly variable. The carapace is dark olive green. A *very* narrow black-bordered red or yellowish line extends from the anterior margin of the nuchal to the notch of the caudals; in some cases this line is almost indistinguishable. The margins of the scutes are yellow, which clearly outlines each scute. The posterior margin of the costal and vertebral scutes is bordered by a narrow black line; the anterior border of these scutes shows a wider line of yellow (sometimes orange, sometimes approaching red), lying against the preceding black line. Vertebrals and costals often with yellow or red lines, dots or blotches, these usually rimmed with black. Marginals with the dorsal surface decorated with lines and spots of yellow and bright red, usually tending toward a concentric pattern around a brilliant red spot near the center of the lateral margin of the scute. This red spot is prolonged down the middle of the ventral surface of the marginals, forming a striking color contrast against the almost black background. The plastron is bright yellow or straw color, often covered with a superficial layer of brown or reddish deposit; it bears a dusky or black-mottled central area extending from the posterior angle of the gulars to about the middle of the anals. This dark area shows no tendency to produce lateral branches along the sutures, especially not along the gular-humeral articulation. The axillary and inguinal elements are largely black, blotched with bright red or orange-yellow. The distal margins of the pectorals and abdominals, which form the bridge, are bordered with black. The more conspicuous of the head and neck markings, all of which show much variation, are usually as follows: On each occipital region is a large yellow blotch, nearly the size of the eye, prolonged backward as a narrower yellow line along the neck; a short, wide dash behind the eye often connects with the previously mentioned spot; a stripe extends from the mid-ventral margin of the orbit downward and backward along the anterior ventral margin of the tympanum, where it meets a short line from the lateral angle of the lower jaw, and together they run as a conspicuous ventro-lateral line down the neck; a short median yellow line begins at the "tooth" of the lower jaw, but

bifurcates to extend down the neck. Between these major lines are many fine lines of yellow. The top of the head is usually mottled, and shows a median line from the nostrils to a point just behind the eyes. The iris is golden brown. Two bright red stripes on the anterior surface of the fore limbs, and three on the under surface of the hind limbs. Tail with yellow or orange stripes. Other soft parts mottled with red and yellow.

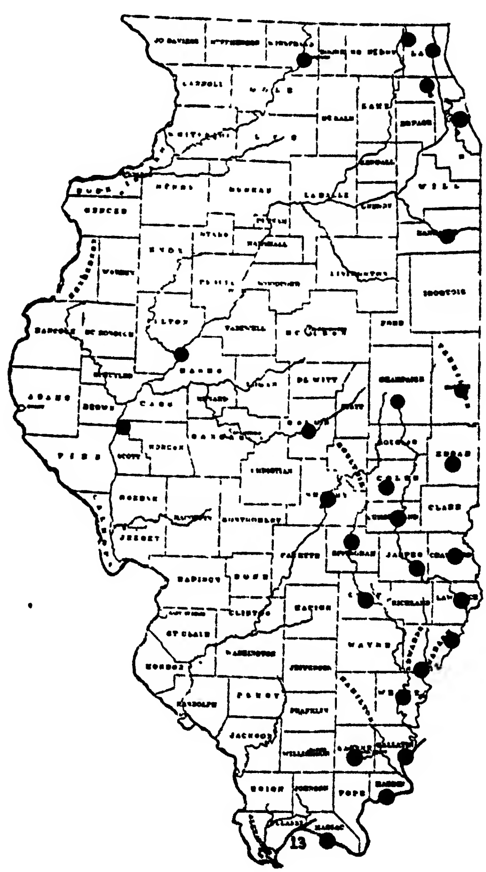
Young.—The newly hatched young are readily recognizable by their resemblance in general form and coloration to the adult. However, the head, instead of being flat dorsally, is convex and highly domed above. The snout is very short; eyes large in proportion to the head. The carapace is nearly circular in outline and very flat and without a keel. Nuchal scute nearly square, the anterior median notch usually not visible. The mid-dorsal stripe is quite clear but is always very narrow, being merely a line. The plastral markings are almost solid black, but of the same shape and form as in the adult.

Sex Differentiation.—The sexes may be distinguished externally by the fact that in the male the claws of the front feet are long, slender, and curved; those of the female are short and stout and but slightly curved. The vent of the male lies beyond the margin of the carapace, of the female, beneath it. The females are larger than the males when fully developed.

Geographic Distribution.—The recent work of Bishop and Schmidt (1931) on the genus Chrysemys enables us to outline the geographic distribution of the various species of the genus with greater clarity than was possible some years ago. *Chrysemys picta marginata* occurs throughout the great territory of eastern United States, extending from eastern New York westward through western Pennsylvania, Ohio, Indiana, southern Michigan, and into eastern Illinois and Wisconsin. The northern and southern limits are very uncertain due to the confusion of names existing in the literature and cannot be accurately defined until a great deal of field work has been done. As an example, *Chrysemys picta* is reported as abundant over the province of Ontario by Nash (1906), and no mention is made of *marginata,* which is probably what he has called *picta* over most of that region. It is not mentioned as an inhabitant of New England by Babcock (1919). Surface (1908) quotes *marginata* from several localities in northwestern Pennsylvania, and incidentally says that "intergrading forms [between *picta* and *marginata*] are rather common," a reference to this matter which Bishop and Schmidt have apparently overlooked. Morse (1904) reports it as one of the commonest turtles in Ohio, and it is reported by Ruthven (1912) from the southern half of lower Michigan. Hay (1892) reports it as "everywhere" in Indiana, and gives its range as the "northern states of the Mississippi

Valley from Ohio to Kansas and north to Lake Superior"—which is both too much and not enough! When we come to Wisconsin, we find Pope and Dickinson (1928) reporting *marginata* as "statewide," with records from the extreme north to the extreme south, and as far west as Grant County on the Mississippi; Hoy (1883) gives it as "abundant everywhere," while Higley (1889) reports it as very common; Cahn (1929) has typical specimens from southeastern Wisconsin, but failed to distinguish the hybrid forms. Since Wisconsin, or part of it at least, lies in the area of overlap of ranges, it is in need of a thorough going over.

Illinois Records.—When we come to Illinois, it is very difficult to know what to do with the published records which cannot be verified by a re-examination of the original material. Since most of the writers did not recognize the hybridization between *marginata* and *bellii* it is extremely difficult to determine just what they were dealing with. We can guess at probabilities, but prefer not to do so. Yarrow (1882) reports *marginata* from Mt. Carmel. Garman (1892) records it "throughout the state; common . . . ." with records from Lake County, Nippersink Lake, Oregon, Normal, Peoria, Phillipstown and Mt. Carmel; Garman (1888) says that it does not occur in the Mississippi bottoms near Quincy, which statement is quite correct. Davis and Rice (1883) do not list *marginata* at all from Illinois, but record *picta* as "abundant throughout the state," which is quite incorrect. Hankinson (1917) is quite frank about his Chrysemys around Charleston, calling them "*Chrysemys* (species?)," though he probably had mostly *marginata* with some hybrids as well. Bishop and Schmidt (1931) report pure *marginata* from southeastern Illinois, but cite no localities. The writer has examined specimens unquestionably *Chrysemys picta marginata* from the following Illinois localities: Paradise Lake at Mattoon, Urbana, Rockford, Havana, Danville, Arlington Heights, Fox Lake, Robinson, Meredosia,



Map 13.—*Chrysemys picta marginata.*

Lawrenceville, Mt. Carmel, Carmi, Louisville, Shawneetown, Harrisburg, Shelbyville, Sims, Metropolis, Effingham, Kankakee, Elizabethtown, Paris, Greenup, and Newton. In preparing the map of distribution of the form, only the above localities where typical *marginata* were examined have been listed. It must be borne in mind, also, that at some localities, as Meredosia, Havana, etc., as well as in the northern counties, hybrids were also present.

HABITAT.—*Chrysemys picta marginata* is a common inhabitant of the smaller lakes, ditches, temporary ponds, and sluggish waters of the eastern and southeastern portion of the state. Its habitat preference is distinctly for shallow, soft-bottomed, weedy lakes, and it distinctly avoids fast water and both rocky and gravelly environments. Almost any muddy ditch or the backwater of a stream or river is likely to have its population of this turtle in surprising numbers. It is associated almost always with an abundant growth of aquatic vegetation, and often the carapace is found to be overgrown with masses of algae. Whether it is the vegetation or the soft bottom accompanying vegetation which is the major attraction would be hard to say, but the combination, usually inseparable, affords the turtle the abundance of food and highly adequate protection in which it finds its optimum environmental requirements. Masses of Vallisneria, Potamogeton, Elodea, and the intertwining nets of algae are likely to shelter great numbers of these turtles.

HABITS.—There is considerable diversity of individual habits exhibited among these turtles, some being highly aquatic, others showing a tendency toward a terrestrial habit. During the summer and fall in particular I have frequently found specimens wandering about in fields and woods nearly half a mile from water, their wanderings having no connection with age, sex, breeding, or hibernation. Such land-journeying specimens are distinctly less timid than the more aquatic ones and, while they mildly resent being disturbed, they quickly recover their equanimity and proceed with their wanderings. Those turtles which show aquatic preferences are very wary and difficult to approach. They spend hours floating at the surface of the water, the head protruding while the body lies partially concealed by the protecting bed of vegetation which they dare not forsake. At the first sign of danger they disappear amid a tiny swirl caused by the sudden action of the hind legs, and are very slow and cautious about again venturing to the surface. As a whole, the species enjoys basking in the sunshine, and the turtles may be seen lined up on partially submerged logs or along the sloping banks of the pond, lazily absorbing the warmth. They lie with their hind legs fully outstretched and entirely relaxed, and with the eyes closed they give the observer the impression of sleeping. But notwithstanding their complete relaxation, the least approach of danger startles them into activity, and they plunge

from their log or scramble down the bank into the water where they bury themselves in the mud at the bottom. Their return to the basking place is slow and cautious, and they do not emerge until the neighborhood has been carefully scanned and inspected.

As swimmers they are fast and powerful when speed is necessary, the flattened hind limbs and the wide webbing of the digits giving them excellent organs of propulsion. When not frightened, however, they walk slowly and cautiously along the bottom, peering to the right and left among the dense vegetation in search of possible food. Again, they may lie for a long period entirely motionless on the bottom, the legs half drawn up, the head just protruding beyond the shell, resting.

When disturbed and handled, the turtles snap vigorously for a time and then seem to take a philosophical attitude and make the best of the situation. Their bite is quite harmless due to the weakness of the jaws, but they are fast in their actions and sure of their aim. In captivity they quickly adjust themselves to their surroundings and in a few days will begin to eat and behave naturally. They can be kept for months or years in a suitable aquarium; they become very tame and eat from the hand within a few weeks after capture.

As the summer wears on and the chill of autumn pervades the air, they become more and more sluggish in their reactions and finally forsake entirely their basking activities. After mid-October, unless the weather conditions are unusual, they are not seen at the surface, and hibernation begins at about this time. They hibernate in the mud at the bottom of the pond, or in the runways of muskrat burrows, or in "cave-ins" along the bank. In the southern portion of the state the hibernation is less marked, and even in the vicinity of Danville the turtles may sometimes be seen crawling slowly and sluggishly along on the bottom during the winter. They reappear shortly after the ice goes out and by mid-April their heads are to be seen poking above the surface, though they do not come out to bask until the air has warmed up to a considerable degree.

Breeding Habits.—Long before the nesting season begins, the turtles become increasingly active, often traveling in pairs, with the male following or chasing the female. Sometimes two or even more males are to be seen thus occupied pursuing a single female; always it is the female that is in the lead. On one occasion I saw the male catch up with the female; he climbed on top of her carapace and seemed to be clawing at her head and neck. However, she quickly evaded him, and when last seen he was again in pursuit. No notes on copulation are available. The nesting habits of the turtles of the genus Chrysemys have been described by Babcock (1919) who quotes observations of Thoreau and others relative to *picta,* while Stromsten (1910) describes the process for *bellii.* That *marginata* is similar to these, the following transcription from my field notes will

bear out. (In one respect at least, the turtles of the genus Chrysemys differ from other species found in the state: they lay in the late afternoon and early evening instead of in the early morning. Thus it happens that the turtle described herewith is a bit unusual only in that it was found digging its nest at 4:10 in the afternoon; it is usually done later.) "The nest was in compact, black soil along the edge of a road, within fifteen feet of a vegetation-choked pond from which her tracks led straight to the point where she was at work. When discovered, the turtle had dug a hole about half an inch deep. She paused for a few minutes, standing motionless while I sat down a yard away, watched me closely, then resumed her digging and paid me no further attention during the process, though I moved considerably in order to watch the performance. Her front feet were firmly planted and were not moved from their position; the digging was done entirely with the hind feet. She scratched several times with one foot; then cupping the foot by drawing the digits together, she carefully scooped the loosened dirt out of the hole and deposited it on the opposite side of the hole behind her. This was then repeated with the opposite foot. As each load was removed, she discharged a stream of water through the cloacal apperture directly into the hole, softening the dirt prior to the scratching that followed. She worked briskly and without pause, one foot after the other removing a pinch of dirt to the growing pile behind her. When she had dug down about two inches, the bottom of the hole was very muddy; from then on no more water was discharged, and this mud was dug out and pushed back. At three and a quarter inches (subsequent measurement) she began to enlarge the bottom of the hole a bit, making a sort of oval chamber, the longer axis parallel with her position. The digging that was watched required sixty-four minutes to complete; then the first egg was laid. In laying, she pulled her head entirely within the shell and, apparently without any effort, deposited the egg in the hole, reaching in with the right hind leg to shove the egg over to one side and to lay it horizontally. The seven eggs that followed were laid at intervals of about one minute, and each was rearranged with the right hind foot after laying. The eighth egg deposited, she remained motionless for about three minutes, then began to fill in the hole. She reached back with one leg after the other and raked small quantities of dirt into the hole, tamping it down with the sole of the foot and occasionally discharging water on it and then tamping it down still more. With the hole almost filled, she seemed to switch from the sole of the foot to the dorsal surface, kneading the dirt into place instead of tamping it down. When the hole was completely filled she watered the spot thoroughly, then repeatedly drew the flat surface of the plastron over it, smoothing the surface. Finally, the front feet still in position, she reached out and drew over the nest an accumulation of

débris, leaves, twigs, dead grass, etc., concealing the last trace of the disturbance. Without looking around to inspect her work, she headed for the pond and disappeared." The entire process under observation required an hour and fifty-two minutes. Regarding the age at which Chrysemys breeds, Agassiz (1857) says that *picta* does not breed until its eleventh summer.

Eggs.—The number of eggs varies from four to ten, with six or seven being the average number deposited. When laid, the eggs are translucent and almost flesh-colored, but as the shell dries out it becomes pure white, opaque and rather brittle. The measurements (in millimeters) of the eight eggs in the set dug from the nest described above are as follows: 30 x 18, 31 x 17, 30 x 17, 30 x 17, 30 x 18, 31 x 18, 31 x 17, 30 x 18; average: 30.3 x 17.6. There is no information available to the writer regarding the incubation period, but young turtles, evidently but newly hatched, have been taken in late August and early September as well as in late June, which inclines the writer to agree with Newman's suggestion (1906) that "forced hibernation of embryos" results when turtles lay late in the season. In spite of the careful effort of the turtle to hide her nesting site, the eggs are very frequently dug up by skunks and raccoons, both of which are experts at discovering these choice delicacies.

A recent note by Wilcox (1933) on the incubation period of the painted turtle (presumably *Chrysemys picta picta*) in New York, is of interest. On June 26 he observed a female digging her nest; on September 8, Wilcox dug down to the nest and found the young turtles just coming out of the shell. They measured almost exactly one inch in length. This gives an incubation period of nine and a half weeks. Nichols (1933) remarks that the above brood was probably unusually advanced for the region and reports eggs laid on July 17, 1925, hatched April 3, 1926, and eggs laid June 25, 1928, hatched October 28 of the same year.

Food Habits.—Hay (1893) reports the food of *marginata* as being "insects, tadpoles and other feeble and small animals." An examination of ten stomachs from specimens from southeastern Illinois leads the writer to make the statement that they are omnivorous, with a strong tendency toward vegetarianism. These stomachs showed the remains of aquatic larvae such as Chironomous and other dipterous forms, nymphs of dragonflies, mayflies and stoneflies, aquatic beetles, gastropods, fingernail shells, small crayfish, tadpoles, ants, flies, and honey bees; only one small, unidentifiable minnow was found. Vegetable matter predominated, being in the form of chewed-up masses of aquatic plants, algae, rootlets, leaves, stems, and grass. Three specimens showed evidence of the scavenger habit; there is no question of the fact that if dead matter is

available, this turtle shows well developed scavenger instincts. When eating anything too large to be swallowed entire, the morsel is held firmly in the mouth and is then ripped to tatters by the claws of the front feet, these feet acting either separately or together.

ECONOMIC IMPORTANCE.—In spite of the abundance of turtles of this genus everywhere throughout the state, their small size makes them undesirable for human consumption, in spite of the fact that the flesh is firm and of excellent flavor. Their scavenger habit makes them a valuable asset in the destruction of animal matter. While they do not ordinarily destroy living fish or fish eggs, it is conceivable that in such places as fish breeding pens these turtles might be a serious annoyance and cause considerable loss.

TABLE 12.—MEASUREMENTS OF ILLINOIS SPECIMENS OF *Chrysemys picta marginata*
(Measurements in millimeters; weight in grams)

Specimen No.	Carapace		Plastron			Head	Tail		Weight	Sex
	Length	Width	Length	Width	Depth		Total	A-T		
1	162	116	148	93	58	24	57	42	484	♀
2	143	110	133	88	52	22	45	40	321	♀
3	138	101	129	81	50	22	47	39	368	♀
4	133	103	125	81	52	21	40	38	363	♀
5	133	98	120	81	43	20	45	39	283	♂
6	133	98	117	77	43	20	51	32	308	♂
7	125	94	116	77	45	19	44	39	266	♀
8	123	96	115	76	43	18	50	37	254	♂
9	122	90	111	70	38	18	55	40	241	♂
10	118	85	102	75	35	17	50	35	176	♂
11	115	87	106	68	42	18	35	32	213	♀
12	82	68	75	65	32	14	44	35	96	♂
13	30	28	28	21	13	8	16	14	6	..
14	27	27	26	20	11	7	12	11	5	..

Chrysemys picta bellii (Gray)

(Western painted turtle; red-legged turtle; mud turtle; pond turtle)

Emys bellii Gray 1831
Emys oregoniensis Harlan 1837
Chrysemys oregoniensis Holbrook 1842
Chrysemys bellii Gray 1855
Chrysemys nuttalii Agassiz 1857
Clemmys oregoniensis Strauch 1862
Chrysemys picta (part) Gray 1863
Clemmys picta (var. b and c) Strauch 1865
Chrysemys pulchra (part) Gray 1873
Chrysemys bellii True 1883
Chrysemys cinerea bellii Boulenger 1889
Chrysemys marginata bellii Stejneger & Barbour 1917
Chrysemys bellii bellii Ruthven 1924
Chrysemys picta bellii Bishop and Schmidt 1931

DESCRIPTION.—Shell broadly ovate, widest posteriorly; depressed and unkeeled; uniformly convex. The posterior lateral marginals flaring. Surface smooth except for occasional longitudinal rugae near the lateral margin of the costal scutes, and extending onto the median of the

marginals. Costal scutes alternating with the vertebrals. Anterior margin of the first vertebral approximately twice the length of the posterior margin and about a quarter greater than the length of the scute. Second and third vertebrals almost equal in size as well as in width; hexagonal; the anterior and posterior borders about equal to the length of the scute. Fourth vertebral wider than long in most of the specimens, and also hexagonal. Fifth vertebral somewhat smaller than the fourth. Costal scutes large, about equalling the width of the vertebrals. First costal trapezoidal, its length and width about equal. Second and third costals wider than long, tending toward rectangular in shape, the third smaller than the second. Fourth costal the smallest of the series, almost square. Nuchal scute elongate but quite wide in most specimens—usually wider than in *marginata;* its anterior margin is usually weakly serrated and the serrations more often than not do not extend to the adjacent marginals. Marginals number 24, with a shallow caudal notch. The marginals follow the slope of the carapace up to the seventh scute, from which region they begin to flare. The plastron is broad and flat and is truncate both anteriorly and posteriorly, the anterior margin finely serrated. Gulars triangular, their anterior lateral angle protruded forward into a weak, blunt "tooth." Interhumeral and interfemoral sutures approximately equal, and the shortest of the median articulations. The interpectoral suture only a trifle longer than either of the preceding sutures. Pectoral scutes transverse, about half the length to the abdominals, which are by far the largest of the plastral elements. Anals large, triangular, the interanal suture but slightly shorter than the interabdominal. The bridge is wide and strong. Inguinal scute larger than the axillary, both irregular in shape. Head moderate and distinctly flat on the dorsal surface and covered with plain, tightly drawn skin. Snout short, not projecting; nostrils anterior, terminal, and set close together. Upper jaw with a distinct median notch which is bordered on each side by a short but definite tooth. The alveolar ridge is weak and poorly developed. Lower jaw only slightly upturned and with a median point which fits into the median notch of the upper jaw. Limbs strong and well developed, especially the posterior pair. Front legs with rows of transverse imbricated scales; digits 5, claws 5. Hind limbs flattened and expanded; digits 5, claws 4, the claw absent on the fifth (posterior) digit. Claws strong, pointed, curved. Toes fully webbed to the base of the claws. Tail slender and attenuated.

Coloration.—The carapace is dark olive green, each scute with a narrow buff margin along its anterior articulation. Other than this, the markings are extremely variable. There is a tendency for each costal scute to show evidence of a diagonal line of buff, or a few irregular transverse lines of red or yellow, and occasionally a few dots. There

is a very narrow mid-vertebral streak of buff or red, often, however, very inconspicuous or almost wanting. The marginals tend to have three transverse streaks, the outer two small and inconspicuous and often buff

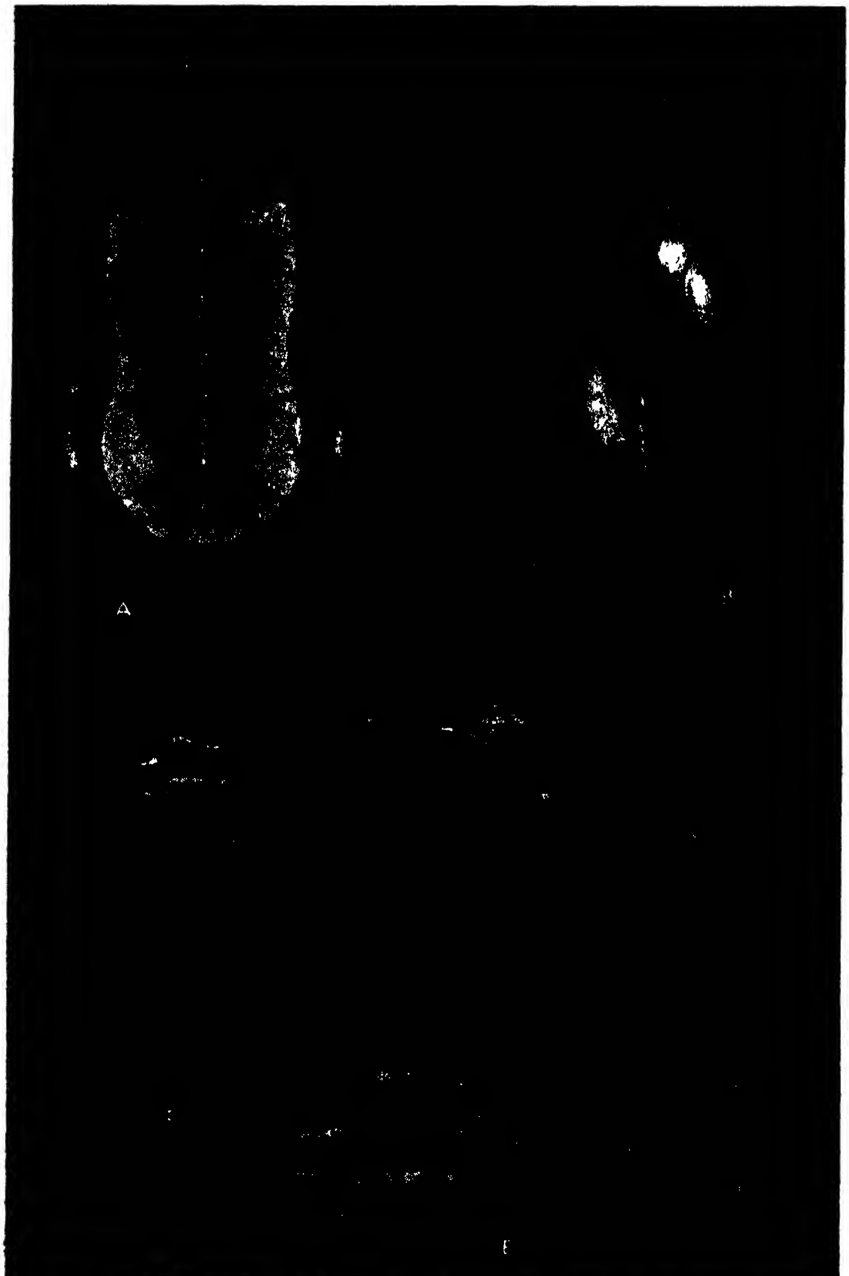


PLATE 18.—*Chrysemys picta bellii: A,* Adult, ventral view. *B,* Adult, dorsal view. *C,* Adult, lateral view. *D,* Newly hatched young, ventral view. *E,* Head study of an adult.

in color, the central one reaching to the lateral margin and blood red in color, terminating in a more or less distinct blotch. Ventrally this red spot is continuous with a brilliant red band, and the marginal scute shows streaks or blotches of buff and red on each side of this band. The bridge is traversed longitudinally by bars, lines, or blotches of red, orange, or buff on a dark olive background, these markings extending over the inguinal and axillary scutes. Inguinal usually with a blood red spot at its posterior lateral angle. The plastron is yellow, sometimes overcast with a brownish or reddish superficial deposit. The central region is marbled with black in a complicated, lyriform, bilateral design. This figure flows out along the sutures and occupies upward of 60 per cent of the area of the plastron. There usually is a clear, longitudinal area within this design, following the mid-ventral suture. The coloration of the fleshy parts is elaborate. The head and neck are striped with blood red and lemon yellow as follows: a yellow stripe from below the nostril to the posterior end of the jaw; two yellow stripes, joined at the nostril, pass through the orbit and terminate dorsal and ventral to the tympanum. Three orange or yellow stripes run along the neck, one starting at the tympanus, one at the corner of the mouth, and one on the occiput. On the ventral surface, a bifurcating yellow stripe starts at the symphysis of the lower jaw and extends back to the body, with a third stripe between these two. Besides these major stripes, many fine yellow longitudinal lines cover the sides and ventral surface of the head and neck. The anterior surface of the fore limbs show two, three, or four broken lines, red on the limb and tending to yellow on each digit; the webbing tends toward a greenish yellow. The posterior limb usually shows three broken red or orange bands, the median the most conspicuous; this one extends onward to the ventral tip of the tail where it unites with its mate from the opposite side. The tail also shows two red lines dorsally which become yellow posteriorly as they unite to extend as a single stripe to the tip of the tail. The vent is usually set in a red spot.

Young.—The young show all of the typical markings of the adult, and, so far as the writer can determine, the markings on the plastron, though blacker and more solid than in the adult, yet retain the same outline and relative proportion throughout life. The young are much more round than the adult, being almost circular in outline. The head is domed above and the eyes are large in proportion to the size of the head. There is never a trace of a keel in the young. The vertebral streak is perhaps a bit more clear in young individuals, but it is always very narrow, a mere line.

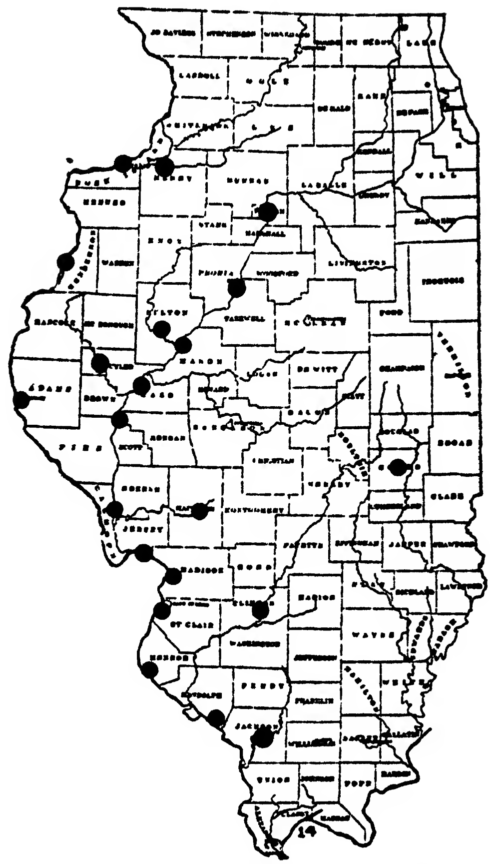
Sex Differentiation.—The sexes may be determined externally by the long claws on the front feet of the male, these being three or four times the length of the claws on the hind foot. They are slender and

curved. In the male the vent lies beyond the margin of the carapace. Fully grown females are larger than fully grown males.

GEOGRAPHIC DISTRIBUTION.—*Chrysemys picta bellii* is a western painted turtle, with a range extending from the Cascade Mountains eastward to the Mississippi River. Storer (1932) gives the status of the species in the far west as follows: "There is thus no definite basis for ascribing *Chrysemys picta bellii* to the region west of the Cascade Mountains. It is a species of the interior, definitely recorded from the Mississippi drainage, Colorado (New Mexico?), and eastern Washington. Like many other vertebrates it evidently circles the northern margin of the Great Basin to reach its limit of range east of the Cascade system." From these mountains, then, the range extends eastward. Blanchard (1922) records it from northwestern Iowa, where he found it to be abundant, and records its breeding. Strecker (1915) reports it from El Paso, Texas. For South Dakota it is reported to be common by Over (1923); Burt and Burt (1929) report it from Nebraska and from Colorado; Burt (1927) records it from eastern Kansas. From Missouri, Hurter (1911) records it for the entire width of the state, and Agassiz (1857) mentions its occurrence at Osage River and St. Louis. Crossing the Mississippi, we are a bit in doubt as to whether all the records of *bellii* deal with this form or with the hybrids, since the eastern limits of the range north of Illinois have not been definitely worked out. Be that as it may, it is reported from Wisconsin by Pope and Dickinson (1928) as "state-wide" in distribution, and by Pearse (1923), who remarks that *Chrysemys bellii* and *C. cinerea* appear to intergrade in the Madison region, "but a majority of the individuals resemble the former." Bishop and Schmidt (1931) record it only from northwestern Wisconsin. In Michigan it is reported only from the western portion of the northern peninsula by Ruthven (1912). In Canada it is recorded for the Lake Nipigon region by Logier (1928). In discussing the distribution of this turtle, Bishop and Schmidt say: "This extension of what is in the main a plains species through the heavily forested area of Wisconsin, Michigan and Ontario seems explainable in part by the highway for dispersal supplied by the valley of the St. Croix and by Lake Superior itself."

ILLINOIS RECORDS.—Here again we have difficulty in sorting out what we may consider records of typical *bellii*. Hurter (1911) records it from Randolph, Monroe, St. Clair, Madison, and Adams counties, all on the Mississippi River, which records are entirely correct. Davis and Rice (1883) do not mention it, but record *picta* as throughout the state, which is certainly entirely incorrect. Garman (1889) reports it from the Quincy region as "rather common in the sloughs, but not seen elsewhere," which is correct. Again in 1892 he reports it from Quincy as very common, in the bottom-lands, but not taken elsewhere in the state. In his inter-

mediate report (1890) he says it is ". . . . closely related to *C. marginata,* but I have not seen in many hundred painted turtles examined during eight years' collecting, an intermediate example." The writer has examined typical specimens from the following Illinois localities: Meredosia, Mattoon, Quincy, Peoria, Havana, Clinton, Hardin, Carlinville, the region directly across the Mississippi River from Burlington, Iowa, Beardstown, Rock Island, Murphysboro, Grafton, Lewiston, Geneseo, and Senachwine Lake in Putnam County.



Map 14.—*Chrysemys picta bellii.*

Habitat.—*Chrysemys picta bellii* shows a decided preference for the sloughs and shallow backwaters of rivers. It is associated with shallow water, usually of a warm temperature, as well as with soft bottom and an abundance of vegetation. In Illinois, at least, it seems to prefer ponds to rivers, and generally avoids current.

Habits.—Its habits are so similar in detail to those reported for the preceding species that it would be largely repetition to reprint them here, and the reader is referred to this section under *Chrysemys picta marginata.*

Nesting Habits.—The nesting of *bellii* has been well described by Stromsten (1910). Field notes made while watching the nesting of this turtle at Meredosia in 1931 check almost exactly with this published description, and since they are so similar to those reported for *marginata,* it seems unnecessary to repeat them. Like *marginata, bellii* digs with the hind legs while the front feet are fixed in position; it applies copious water from the cloaca to the material to be dug from the hole, and finally, during the laying of the eggs, it uses the hind foot to arrange the eggs in position within the nest.

Eggs.—The number of eggs laid varies from four to ten, with six or seven being the normal number. When laid the eggs are flesh color and

translucent, and the shell dries white and opaque. A typical set of eggs measures as follows (in millimeters): 36 x 18, 35 x 18, 36 x 18, 36 x 18, 34 x 18, 34 x 17, 34 x 18, 34 x 18; the average size of 41 eggs composing seven complements is 34.7 x 17.8. They tend apparently to be a trifle larger than those laid by *marginata*. The young usually hatch in August or early September, but newly hatched individuals in June indicate again the possibility of embryonic hibernation.

GROWTH.—The only recent paper dealing with the growth of any of our common turtles is that of Pearse (1923), who worked on Chrysemys at Madison, Wisconsin. Pearse recognized the "intergrade" condition of the Chrysemys of that region and says that the Madison turtles resemble *bellii* more than *marginata*. Therefore, while he was probably studying largely hybrid turtles, his results are interesting and probably approximate very closely the condition in either pure *bellii* or *marginata*. He captured his turtles, measured and tagged them, and turned them back to be recaptured at a later date. Table 13 is taken directly from his paper. His conclusions, based on this table are that "a turtle nearly doubles its length and weight during the second year of its life. After twelve years it would be about 135 mm long, and the growth rate would have decreased to about one-thirtieth of that during the first two years. An ordinary adult turtle measuring 150 mm in length is, using the data here presented as a basis for computation, about twenty-five years of age." Unfortunately, Pearse does not state clearly what his criterion for age determination of turtles is; nor does Agassiz (1857) make it much clearer when he deals with *picta* and records its age-length relationship as follows: 1st year 26.5 mm; 2nd year 42 mm; 3rd year 51 mm; 4th year 54 mm; 5th year 59 mm; 6th year 66 mm; 7th year 72 mm; 8th year 74 mm; 9th year 77 mm; 10th year 80 mm; 13th year 92 mm;

TABLE 13.—GROWTH OF TURTLES OF DIFFERENT LENGTHS

Length: mm.	No. of records	Av. rate of growth: mm. per year	Estimated av. weight: grams	Estimated av. wt. increase: gms. per year	Percentage increase
40-50	2	32.7	19	13.8	73.0
50-60	10	17.0	36	11.1	31.0
60-70	12	16.7	50	12.7	25.0
70-80	8	19.0	68	15.9	25.0
80-90	3	4.2	106	5.2	5.0
90-100	11	6.0	134	8.5	6.0
100-110	13	3.5	170	5.7	3.3
110-120	8	3.1	233	6.3	2.7
120-130	6	4.2	243	8.2	3.4
130-140	8	1.5	310	3.4	2.4
140-150	6	1.6	362	3.9	2.7

24th year 121 mm. Agassiz further reports for *Chrysemys picta* that "up to their seventh year the ovary contains only eggs of very small size, not distinguishable into sets; but that with every succeeding year there appears in that organ a larger and larger set of eggs, each set made up of the usual average number of eggs which this species lays, so that specimens eleven years old, for the first time, contain mature eggs, ready to be laid in the spring." He further reports that fecundation occurs in the fall prior to hibernation, and that the act is repeated in the spring, starting with the seventh year of the turtle's life. Just what the significance of this is has never been determined, but Agassiz believes that "fecundation does not appear to be an instantaneous act, resulting from one successful connection of the sexes, as it is with most animals. The facts related above show, on the contrary, that, in turtles, a repetition of the act, twice every year, for four successive years, is necessary to determine the final development of a new individual . . . ." There are some very interesting and somewhat difficult research problems involved in these ideas of Professor Agassiz! To these facts the writer would add that females from Paradise Lake at Mattoon measuring 106 mm in length contained tiny embryonic eggs while females 160 mm long contained at the same time eggs about to be laid.

TABLE 14.—MEASUREMENTS OF ILLINOIS SPECIMENS OF *Chrysemys picta bellii*
(Measurements in millimeters; weight in grams)

Specimen No.	Carapace		Plastron			Head	Tail		Weight	Sex
	Length	Width	Length	Width	Depth		Total	A-T		
1	179	133	166	115	63	26	55	45	720	♀
2	160	115	148	102	59	24	48	40	540	♀
3	158	121	146	98	51	23	49	39	510	♀
4	145	115	142	94	52	21	50	40	429	♀
5	114	103	130	87	44	22	60	41	359	♂
6	113	72	107	94	36	18	..	..	187	♂

Chrysemys picta dorsalis (Agassiz)

(Southern painted turtle; red-legged turtle; mud turtle; pond turtle)

Chrysemys dorsalis Agassiz 1857
Chrysemys picta (part) Gray 1863
Clemmys picta (var. d) Strauch 1865
Chrysemys cinerea dorsalis Boulenger 1889
Clemmys cinerea (part) Strauch 1890
Chrysemys marginata dorsalis Stejneger and Barbour 1923
Chrysemys picta dorsalis Bishop and Schmidt 1931

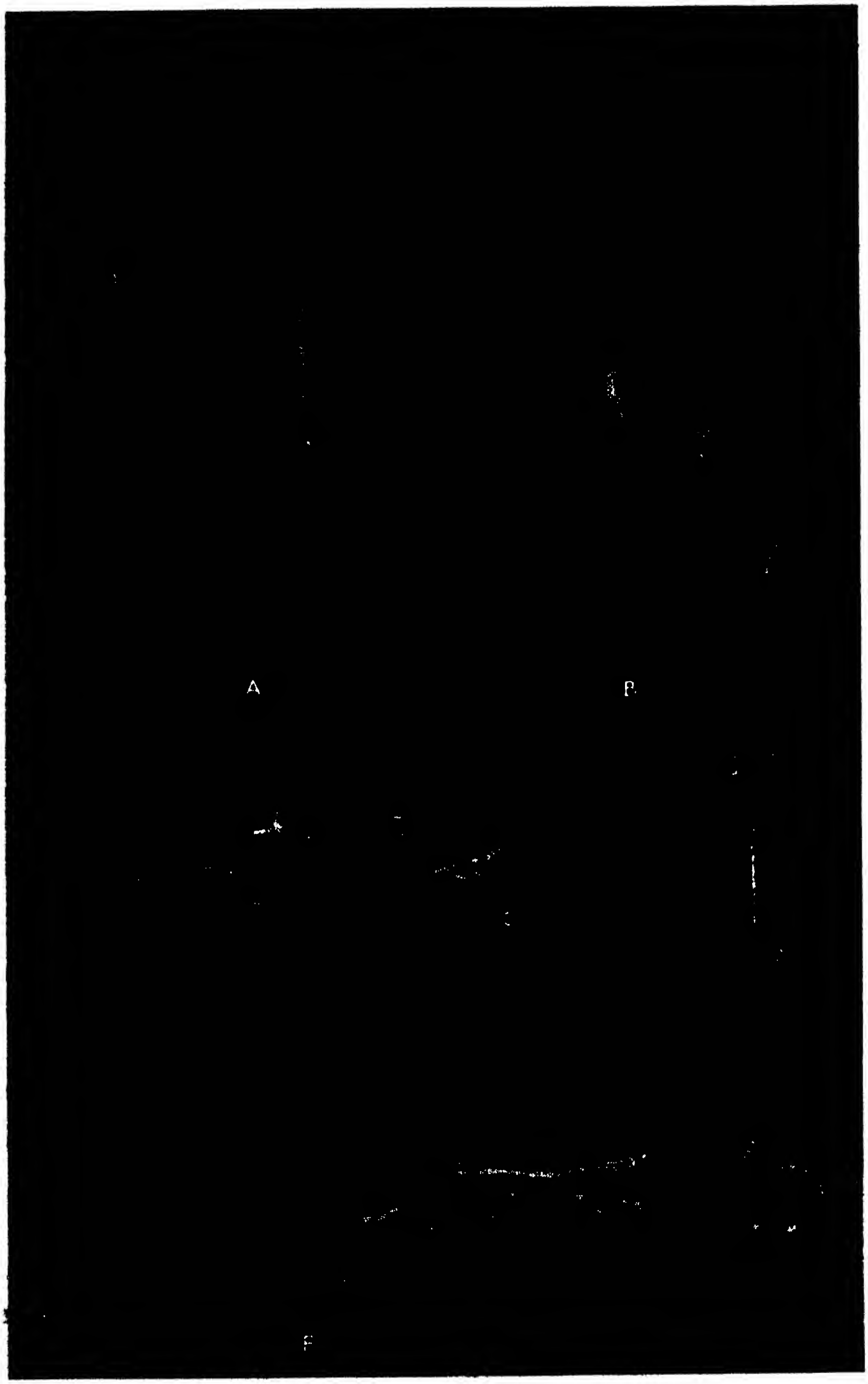


PLATE 19.—*Chrysemys picta dorsalis; A,* Adult, ventral view. *B,* Adult, dorsal view. *C,* Adult, lateral view. *D,* Newly hatched young, dorsal view. *E,* Newly hatched young, photographed to bring out the granular surface of the scutes. *F,* Head study of an adult.

Description.—Shell elliptical in outline, occasionally tending toward broadly oval; depressed and without a trace of a dorsal keel. The outline of the shell tends to be wider than in either *marginata* or *bellii*, and to be slightly less depressed. Marginals flaring posterior laterally, the curvature of the rest of the shell being gradual and uniform. The vertebral series of scutes is very wide, much wider than in either *marginata* or *bellii*, the width of these scales considerably exceeding the width of the costal scutes. First vertebral trapezoidal, about the length of the second, but distinctly narrower; its anterior margin greatly exceeds its posterior margin. Second, third, and fourth vertebrals broader than long, and broader than the costals, with the anterior lateral borders approximately equal to the posterior lateral borders. The middle three costals nearly equal in size, the fifth being much smaller and the shortest of the series. Nuchal long and narrow, usually with a very small median notch. Anterior border of the first marginal often but not necessarily finely denticulate. Posterior margin of the carapace either weakly serrated or unserrated, and with a very small median (caudal) notch. Plastron very large and wide, fully equalling the opening of the shell, exceeding in this respect the plastron of both *marginata* and *bellii;* both anterior and posterior lobes truncate. Length of the posterior plastral lobe approximately one-half the width of the plastron, about equalling the total width of an abdominal scute at the point of the bridge. Gulars with a finely denticulate anterior margin, and with the anterior lateral angles slightly prolonged into a small knob. Pectoral scutes narrow. The interanal suture is usually the longest, but in some cases is equalled, and in a few exceeded, by the interabdominal suture. The interhumeral and interfemoral sutures are the shortest and are usually approximately equal, though either may be a bit shorter than the other. In only one specimen on hand the interhumeral is shorter than the interfemoral suture. Inguinal large, axillary small. Head moderate in size. Snout short and bluntly pointed; nostrils anterior, terminal, and close together. Upper jaw with a small median notch and with a very small cusp on each side of it; the cutting edge is practically smooth, but sometimes with very faint denticulations. Alveolar surface narrow, with poorly developed median ridge. The limbs are strong; digits fully webbed to the base of the claws; claws 5-4, short in females, long in males. Tail slender, its proportions varying with the sex of the individual.

Coloration.—Carapace much less highly decorated than in either of the preceding species. Carapace dark brownish olive to nearly black. The mid-dorsal line is usually wide and very conspicuous; it starts at the tip of the nuchal and extends through or onto the caudals, sometimes bifurcating on the latter. It varies from yellow to blood red; often it is

vermillion. Anterior and anterior-lateral margins of the second, third, and sometimes the fourth vertebral scutes bordered with straw-color or yellow. Anterior margins of the second, third, and fourth costal scutes bordered with the same color. Individuals show a great variation in the width and conspicuousness of these color bands, but they are much more pronounced than in *marginata* or *bellii*. The marginals show little red dorsally, the area being confined usually to a single short, transverse line or a spot at the margin; the remaining marks consist of lines, comas, U- and S-shaped marks of straw yellow. Plastron uniformly yellow (Hurter (1911): "deep red in spring;" a condition the writer has never seen in spring specimens). Ventral surface of the marginals with bright red median area, bordered toward the sutures with black or dark olive, which dark areas contain irregular yellow mottlings. Axillary and inguinal scutes marked with red and yellow on the same dark ground color. Usually a dusky longitudinal area across the suture between the marginals and the lateral edge of the wing of the pectoral and abdominal scutes on the bridge. Soft parts dark olive, almost black, striped with yellow and red, those markings on the head and neck showing much variation but usually as follows: a yellow band from under the nostrils to the angle of the upper jaw; a yellow line from the dorsal margin of the nostril, running through the orbit and stopping shortly beyond it; two yellow bands, often quite broad, start above and below the angle of the jaw, shortly unite and extend as a broad band down the neck, grading into vermillion about half-way down the neck; a yellow line starts on the tympanum and extends down the neck; a broad yellow band starts at the posterior lateral dorsal portion of the occiput and extends down the dorsal lateral side of the neck, grading into vermillion and branching near the body to send a posterior branch toward the front leg. On the ventral surface, a yellow line starts at the symphysis of the lower jaw and quickly bifurcates, enclosing an olive area with yellow lines within it; these yellow lines grade into vermillion and fuse again into a single red line near the base of the neck. Between these more conspicuous lines are many faint and irregular lines of straw yellow. The top of the head is mottled and lined with the same color. Fore limbs with two conspicuous yellow-bordered red bands and irregular yellow lines. Hind limbs lined and dotted with yellow-margined red areas. Flesh of the axillary and inguinal regions of a similar color. Tail with two dorsal lateral yellow lines.

YOUNG.—Nearly circular in shape. The carapace of newly hatched individuals tends to be a trifle less depressed than in the other turtles of the genus, and as the vertebrals have quite a slope, the median line is quite sharp, giving a hint of a very slight keel. The surface of the carapace is finely granular in these newly hatched individuals, but this

granulation disappears at an early date. The mid-vertebral stripe is wide, brilliant, and very conspicuous, but the yellow edges of the vertebral and costal scutes are entirely absent (28-mm specimen). The dorsal surface of the marginals shows a conspicuous lateral marginal spot of red, and the remaining dorsal surface of these scutes is finely reticulate. The ventral marginals show a red area near the anterior suture, with a black area toward the posterior margin, this dark area with a median yellow line. The major color lines described above are usually clearly indicated.

Sex Differentiation.—Males with claws on the second, third, and fourth digits of the fore limb; long, slender, and curved. Tail of the male is just short of being half the length of the plastron, and less than a third that of the plastral length in the female. In the male the anus opens well beyond the posterior margin of the carapace.

Geographic Distribution.—*Chrysemys picta dorsalis* is distinctly of southern and southwestern distribution, the exact limits of whose range cannot at the present time be stated with accuracy. Hurter (1911) gives its range as "from the Gulf of Mexico up the Mississippi River to the southeastern part of Missouri." Siebenrock (1909) reports it from Mississippi and Louisiana, while Yarrow (1882) records it only from Mississippi. Hurter and Strecker (1909) record it from northeastern Arkansas. Hurter (1911) reports it from the extreme southeastern corner of Missouri, to which Blanchard (1924) adds another record for the same region. In Louisiana, Beyer (1899) reports it as of general distribution in the state west of the Mississippi, but not common. It is not recognized at all by Davis and Rice (1883). The writer has taken it commonly at Reelfoot Lake, Tennessee. Apparently, then, the range is limited to the lower Mississippi Valley, and for the most part to the region west of the river.

Map 15.—*Chrysemys picta dorsalis.*

Illinois Records.—There is no published record of the occurrence of this turtle in Illinois. The writer first became acquainted with the species in the Reelfoot Lake country, where it is very common. Subsequent search in southern Illinois brought some thirty specimens from Cairo, Metropolis, Chester, and Horseshoe Lake in Alexander County. In all of these localities typical *dorsalis* was found, as well as a number of the hybrid forms previously discussed. It is not, however, common in the state. We must say, then, that *dorsalis* is confined to the extreme southern tip of Illinois, with a slight extension of its range up the Mississippi River to Chester.

Habitat.—*Chrysemys picta dorsalis* is distinctly more of a pond turtle than an inhabitant of rivers or streams, and shows more decided preferences in this direction than either of the preceding two members of the genus. In the southern tip of the state it is found in shallow weed-choked or rush-grown ponds, often temporary in nature, and often in water but a foot or less in depth. In consequence of the shallow nature of these ponds, the water therein has a higher temperature than is found in the deeper neighboring bodies of water at the same time of the year. It is often found in the over-flow ponds and backwaters of the Mississippi and Ohio rivers, as well as in the more permanent lakes.

Habits.—So far as the writer has observed, *dorsalis* is very similar in its habits to *marginata* and *bellii,* except that it is perhaps a trifle more aquatic. It is most frequently seen with its head out of water, but cannot possibly be identified when thus placed unless one knows it to be the only Chrysemys in the region. During the warm days of spring and all through the hot summer, these turtles enjoy basking on exposed logs, lying relaxed as is common to the members of this genus. They are very timid, and scurry into the water when the least suspicious of danger. I have watched them thus sunning themselves in Horseshoe Lake and note that once disturbed, they are very slow about reappearing in their basking places. They are strong swimmers when necessity demands, but when undisturbed they may be seen walking slowly over the bottom in search of their food. They can remain under water for a long time, as observed in the laboratory, but in nature the duration of their submergence is very difficult to determine because of the numbers of the turtles generally present and the density of the aquatic vegetation which may effectively conceal their inconspicuous heads when poked to the surface. Except during the breeding season when they search for a nesting site, and in the event of the evaporation of their secluded pond when they are forced to migrate, the turtles rarely leave the water, though they are capable of easy and rapid locomotion on land. That they leave their aquatic environment reluctantly is illustrated by the fact that when Horseshoe Lake dried up in 1930, hundreds of shells of these turtles were found

scattered over the lake bed, though the turtles would not have needed to migrate far to have found water. Might one guess that because the drying up of Horseshoe Lake was a new experience to the turtles living in it their migratory "mechanism" failed to function as it does in turtles living in ponds that regularly go dry? I noticed the same condition during the 1930 "low level" record of Reelfoot Lake in Tennessee: a pond, not connected by water to the lake, which under normal conditions would have measured some hundred yards in each direction, had dried up completely, and in the bed of this "dead" pond I found 116 dead *dorsalis,* with no other species of turtle represented. Yet in similar ponds half a mile away which had not dried up, I found *dorsalis* associated with many *Pseudemys elegans, P. concinna,* and *P. troostii.* There is no evidence either way on the subject of hibernation of this turtle in Illinois, but the writer doubts, because of the relative mildness of the climate in the region inhabited by the turtle, that the species goes into any prolonged period of winter inactivity, if, indeed, it hibernates at all.

Nesting Habits.—I have not been fortunate enough to have seen *dorsalis* digging its nest, and no description of the process exists in literature. Yet at Horseshoe Lake I came close to it in June, 1930, when I caught a female just as she had finished her nest and was departing for the water. The nest was typical of that constructed by the other Chrysemys species, and contained six eggs. The nest was dug out, and it was noted that the soil was wetter than in the surrounding undisturbed area, indicating again the discharge of water from the cloaca during the process of nesting.

Eggs.—The six eggs referred to above constitute the only set of eggs of the species the writer has been able to obtain. The eggs are

Table 15.—Measurements of Illinois Specimens of *Chrsyemys picta dorsalis*
(Measurements in millimeters; weight in grams)

Specimen No.	Carapace		Plastron			Head	Tail		Weight	Sex
	Length	Width	Length	Width	Depth		Total	A-T		
1	132	105	125	89	46	19	41	36	307	♀
2	132	104	125	88	46	20	40	32	300	♀
3	127	100	119	87	47	20	41	32	274	♀
4	128	98	123	83	42	20	42	34	249	♀
5	126	100	119	81	45	19	42	35	265	♀
6	125	102	120	89	51	20	40	30	304	♀
7	122	100	116	91	41	18	35	26	252	♀
8	114	91	107	76	42	18	43	31	200	♀
9	104	88	98	75	40	17	39	30	172	♀
10	100	83	92	71	35	17	35	26	131	♀
11	99	75	80	60	29	14	40	25	91	♂
12	87	70	80	60	33	15	30	22	103	♀
13	81	66	72	55	28	13	42	29	74	♂
14	81	66	71	55	26	14	37	22	60	♂
15	83	68	78	55	30	14	36	21	79	♂
16	27	28	25	21	11	8	16	13	5	Im.

indistinguishable in size and texture from those of the other species of the genus, and it is very doubtful whether it would be possible to tell the eggs of *marginata, bellii,* and *dorsalis* apart by any means other than hatching. These eggs measure as follows (in millimeters): 31 x 19, 31 x 19, 30 x 20, 32 x 19, 33 x 18, 31 x 18, with an average of 31.3 x 18.8. No information as to the incubation period is available, but young turtles, evidently but recently hatched, have been sent to the writer from Cairo and Metropolis in both June and September.

Food Habits.—The food habits of *dorsalis* are very similar to those of the preceding species of the genus, being distinctly omnivorous, with about an equal mixture of animal and vegetable matter usually found in the stomach. Of animal life, the following has been found: tadpoles, small crayfish, phyllopod crustaceans, gastropods, and an assortment of the larger aquatic insects and larvae, diving beetles (Dytiscus), Corydalis larvae, mayfly and dragonfly nymphs, Notonecta and caddis worms. Of vegetable matter, the chewed-up remains of grass, rootlets, and a variety of unidentifiable aquatic plants are almost always present. The scavenger habit is well developed and is indulged in when opportunity permits.

Genus Pseudemys Gray

Pseudemys Gray 1855
Ptychemys Agassiz 1857
Trachemys Agassiz 1857
Nectemys Agassiz 1857
Callichelys Gray 1863
Redamia Gray 1870
Chrysemys (part) Boulenger 1889

Shell somewhat depressed, but not as much so as in the genus Chrysemys; posterior margin of the carapace serrated. Plastron truncate anteriorly, emarginate posteriorly. Abdominal and pectoral elements with well developed wings; axillary and inguinal elements approximately equal in size and relatively large. Alveolar surface of the jaws wide, and with a median ridge extending parallel to the margins. Digits fully webbed; 5-4 in number. Anterior digits long, with curved claws; fifth digit on the hind foot without a claw and in the form of a projection on the posterior margin of the foot. Fore limbs with rows of scales. Young with a distinct keel which may or may not persist in the adult stage.

Pseudemys concinna (LeConte)

Testudo concinna LeConte 1830
Terrapene concinna Bonaparte 1830
Emys annulifera Gray 1831
Emys concinna Duméril & Bibron 1835
Emys labyrinthica LeSueur (Duméril 1851)
Pseudemys concinna Gray 1855
Ptychemys concinna Agassiz 1857
Malacoclemmys geographica (part) Agassiz 1857
Clemmys concinna Strauch 1865
Emys orthonyx Wied 1865
Trachemys annulifera Gray 1873
Chrysemys concinna Boulenger 1889
Chrysemys labyrinthica Hay 1892
Pseudemys labyrinthica Baur 1893
Pseudemys vioscana Brimley 1928

Description.—Shell moderately depressed; carapace oval in outline, the point of maximum width varying with age, but in adults this region is usually in the immediate vicinity of the eighth marginal scute. Sides

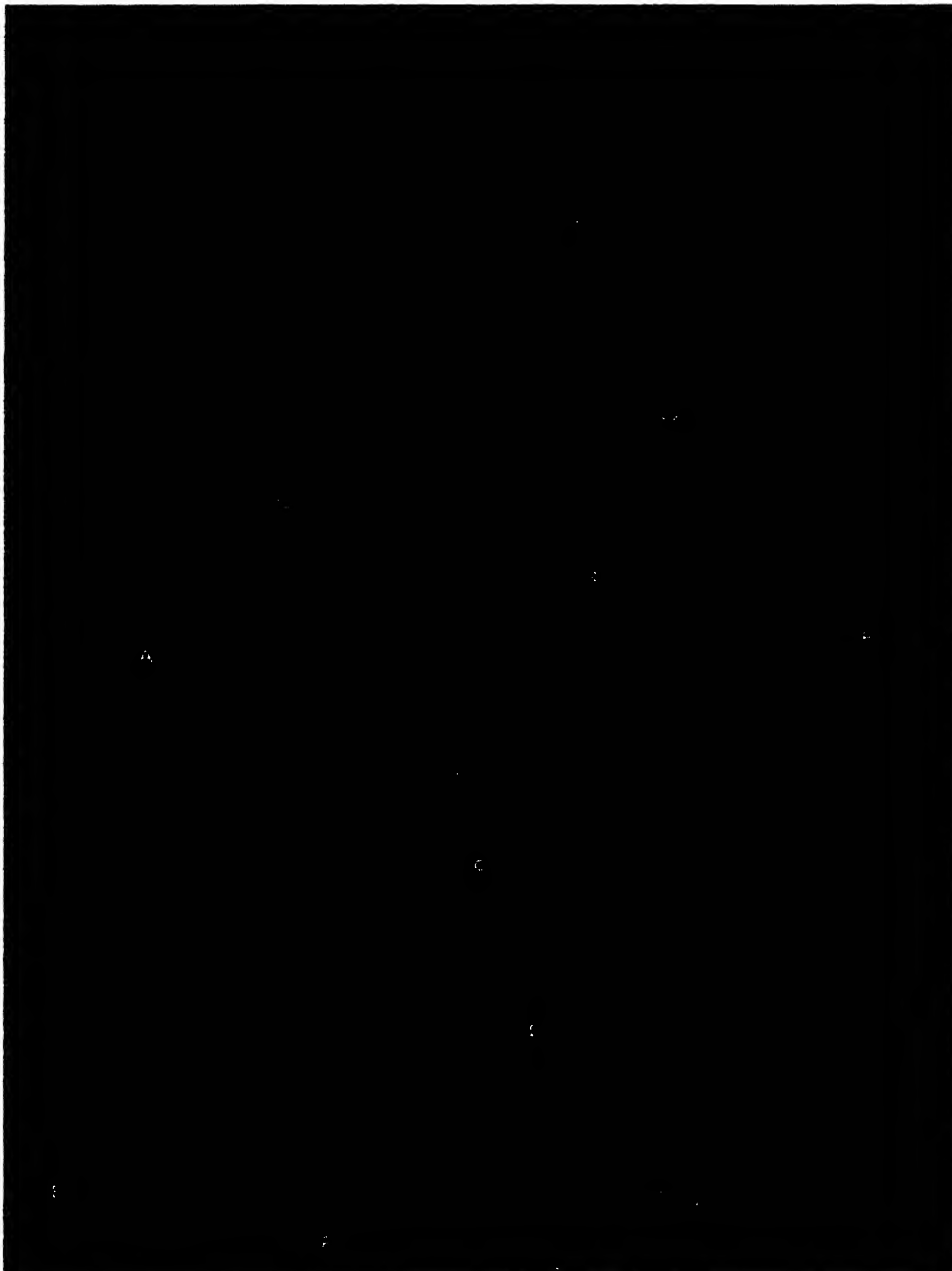


Plate 20.—*Pseudemys concinna:* *A,* Adult, ventral view. *B,* Adult, dorsal view. *C,* Adult, lateral view. *D,* Immature individual, lateral view; length, six inches. *E,* Same immature individual, ventral view. *F,* Newly hatched young, dorsal view. *G,* Head study of an adult.

with uniform slope, but with a distinct posterior flare involving the marginals from the seventh backward; anterior flare less marked. First vertebral scute urn-shaped, its lateral borders sinuous; second, third, and fourth vertebrals approximately as wide as long, and narrower than the costals; fifth vertebral wider than long, approaching trapezoidal. Costal scutes with more or less conspicuous lateral, longitudinal rugae. Anterior three costals very large, all three wider than long; fourth costal much smaller and with its length and width about equal. The first costal is triangular; the remaining elements of the series quadrangular. Nuchal elongate, nearly twice as long as wide, its anterior margin straight. Anterior margin of the carapace with a shallow, rounded emargination involving the first pair of marginals and the nuchal. Posterior marginals with their posterior angles produced to form a serrated edge, beginning usually at the ninth scute and ending with an acute median posterior notch between the caudals. Plastron large. Gular with a bluntly rounded anterior-lateral angle. Pectoral scutes much wider than long. Abdominals very large. Posterior margin of the plastron with a deep median notch. The interabdominal suture is the longest; the interhumeral the shortest. Axillary and inguinal elements large, the latter protruding forward so as to cut off the greater part of the wing of the abdominal from contact with the marginals. Bridge wide, the angle of slope toward the carapace varying with the size (age) of the individual, being most abrupt in young specimens. Head moderate in size, the snout short and blunt. Upper jaw without a median notch or hook, the cutting edge entirely smooth, not serrate; alveolar ridge strongly tuberculate and wide throughout. Lower jaw very flat and with a median tooth; cutting edge serrated. Limbs strong, the digits fully webbed; claws 5-4. Tail short and stocky.

Coloration.—Carapace with the ground color varying from brownish to olive green, with a superimposed complicated design of yellowish lines. In a general way these lines tend to run longitudinally upon the vertebral scutes and transversely upon the costals. On the costals these lines tend to form into concentric areas of indefinite shape, bordering on circles. In some specimens the costals bear a transverse yellow bar as conspicuous as that found in *Pseudemys elegans*. Marginals with a transverse yellow bar near the middle. On each side of this is a thinner yellow crescent, opening toward the adjacent suture, within which crescent is a poorly defined yellow spot; the crescents of adjoining scutes thus tend to form a circle containing two yellow spots. The plastron is uniformly yellow or straw color, or with a few dusky spots or symmetrical dusky areas on the gulars and humerals. The amount and placement of these darker areas exhibit great variation. Bridge, axillaries, and inguinals with dusky longitudinal areas. Ventral surface of the marginals yellow, with large crescent-shaped dusky areas containing one

or more yellow spots. Head and neck dark olive, striped with yellow or yellow-green. A straight line extends from the snout to a point just posterior to the orbit. Another line starts at the orbit, extends backward and widens on the neck. A third stripe starts at the posterior angle of the orbit and extends backward and downward, joining by a vertical branch, which passes the anterior margin of the ear, a fourth stripe which starts at the mid-ventral margin of the orbit. This fourth stripe is very wide and conspicuous. At the posterior angle of the mouth this stripe is joined by a conspicuous band from the mid-lateral margin of the lower jaw, thus forming a large "Y" around the posterior angle of the mouth. From the symphysis of the lower jaw a stripe starts backward, to bifurcate and extend as two irregular stripes down the neck. Often another stripe is to be found between these bifurcations. The upper jaw is lined with yellow. Tail, limbs, and feet with conspicuous yellow lines. The skin in the inguinal region is white, immaculate.

YOUNG.—The young possess a distinct median keel, which disappears in individuals about half-grown, leaving no trace in the fully adult specimens. This keel is most marked on the posterior part of the second, on the third, and on the anterior part of the fourth vertebral scutes. The plastron shows considerable dusky color, arranged in symmetrical design which is usually more pronounced on the anterior elements, and faint traces of portions of this pattern may remain even in very large, mature individuals. There are usually two black spots on the bridge. The snout is very short and blunt; the eyes are prominent. Young specimens tend to have their maximum width near the middle of the carapace, this shifting posteriorly with age.

SEX DIFFERENTIATION.—Males with claws of second, third, and fourth digits of the fore feet exceedingly long, at least three times the length of the other claws. The tail is longer in the male than in the female, and the anus lies beyond the rim of the carapace in male individuals.

GEOGRAPHIC DISTRIBUTION.—*Pseudemys concinna* is a southern turtle which, for some reason or other, is hardly mentioned in lists or in literature dealing with regional herpetology. Siebenrock (1909) records it as from the southern states, from Missouri and North Carolina to the Gulf of Mexico, excluding Florida; Boulenger (1889) gives a similar range, but does not exclude Florida. Loennberg (1894) reports it as the commonest "cooter" in Florida! Stejneger and Barbour (1923) locate the range as "the eastern rivers from Georgia to southern Maryland." For Louisiana, Beyer (1899) reports it as common in the southern portions but rarer inland except near large bodies of water; Strecker and Hurter (1909) say that specimens from Arkansas previously reported as *P. concinna* are in fact *P. texana,* a western close relative. Strecker (1915)

corrects Yarrow (1882) in the report of *P. concinna* from Texas, saying these are probably *P. mobilensis* Holbrook, and he further points out the hopeless confusion in Texas records of *texana* and *mobilensis*. Hay (1892) includes it in his Indiana list on the basis of the report of Garman (1892) from the Wabash River, though he has no further records to add. Rhoades (1895) records it from Tennessee, and the writer has taken exceedingly fine, large specimens in abundance from Reelfoot Lake in that state. It is not recorded from Alabama by Haltom (1931). The writer has a suspicion that the two new species of the genus Pseudemys described by Brimley (1929) under the names of *P. vioscana* (Louisiana) and *P. elonae* (North Carolina) are synonymous to *P. concinna*, or at best, subspecies of it.

Map 16.—*Pseudemys concinna.*

Illinois Records.—The only published Illinois record for *Pseudemys concinna* seems to be that of Garman (1890; 1892) of a specimen sent him by Dr. Shenck from Mt. Carmel, on the Wabash River, for it is not mentioned by Davis and Rice (1883). The writer has specimens from the following localities: Mt. Carmel, Chester, Metropolis, Cairo, Elizabethtown, Murphysboro, Union County, and Horseshoe Lake in Alexander County.

Habitat.—In the southern portions of its range, in which it is an abundant species, *Pseudemys concinna* apparently frequents brackish water, according to True (1884). In the northern limits of its range, however, the turtle is found only in the larger rivers and lakes, avoiding the smaller streams and temporary ponds. It is abundant among the cypresses of Reelfoot Lake, Tennessee, where the relatively warm, shallow water and the abundance of aquatic vegetation seem to afford it a most congenial environment, for specimens reaching a length of 375 mm and a weight of over 4000 grams are not at all rare there. The shallow water of Horseshoe Lake in southern Illinois affords it a congenial

habitat, but here the specimens do not attain nearly so great a size. In this lake the species was exterminated when the lake went dry in the late summer of 1930; it will be interesting to note whether the species rehabilitates itself there. It has not done so to date (1933). When associated with the larger rivers, the turtles are most frequently met with in the backwaters and in the sluggish bays, seldom out in the main channel. Quiet, shallow, warm water, and an abundance of vegetation on a soft bottom seem to be their environmental requirements.

HABITS.—In 1892 Hay wrote that "not much appears to be known about the habits of this terrapin," and the same can truthfully be written after a lapse of forty years. It has been sadly neglected and should be thoroughly investigated in the south where it reaches its optimum; it is too rare in Illinois to do much with except over a long period of time. The observations herein recorded were made at Reelfoot Lake, and from notes and material submitted to the writer from this lake and from Horseshoe Lake in Alexander County, Illinois, by field workers.

Pseudemys concinna is decidedly aquatic in its habits. It seldom leaves the water except to lay its eggs, spending most of its time in water from two to five feet deep. It spends a large part of the time submerged, either resting on the bottom or walking slowly about in quest of food, coming to the surface periodically for air. When at the surface, only the head protrudes, the shell remaining at an angle of about 45°, completely hidden. In this position the turtles remain for a long period, apparently motionless, but this surface drifting is only done when the water is smooth; if there are any waves at all they get their air immediately and submerge again. They are fond of basking, and crawl out on submerged logs or up on cypress knees, and remain for hours enjoying the warmth of the sun. I have seen logs lined with an assortment of *P. concinna, P. elegans, P. troostii,* and *Chrysemys picta dorsalis,* so thickly that sometimes they are piled up two deep. *Pseudemys concinna,* however, is very timid and wary; constantly on the lookout for danger, the least suspicious movement sends them off into the water, and once frightened, they are very careful for hours afterward. I have spent hours trying to capture specimens with a long handled dip net from a silently paddled boat, almost always without success. While they utilize every possible basking space available out in the water, I have never seen one basking on shore.

On land they are rather slow and awkward, due to the bulk and weight of the shell, and among the tangle of cypress knees they have great difficulty in traveling on shore. When the fishermen take in their fish nets they frequently have many of these turtles in their catch. If they throw them ashore into the woods, as they frequently do, a great many of them never succeed in regaining the water, as witnessed by the

numerous skeletons I have found about the lake. The large turtles get penned up by the cypress knees and cannot climb over them or apparently find their way out of the maze. They show little intelligence in solving the problem and the result is often fatal. If taken from the water and placed on land, the turtles show no offense whatever, neither attempting to escape nor to bite. The head and neck are drawn in as far as possible, and the legs pulled up under the shell, and thus they are likely to remain for hours. Once they get under way their progress is quite slow, while in the water their movements are powerful and rapid. They are excellent swimmers.

NESTING HABITS.—The building of the nest has never been described so far as the writer knows, and he has no data to offer other than that they nest in sandy localities not far removed from the water. The season of nesting is reported as early June for the Reelfoot Lake country, and this would seem, from the condition of the eggs taken from females by dissection, to be about correct. While the writer has several sets of eggs dug from nests, no nest so far discovered has been more than about 100 feet from water.

EGGS.—A large female of *Pseudemys concinna,* sent to the writer from Reelfoot Lake in late May, 1931, had nine eggs in the oviduct, with the shell already deposited. The eggs were all ready to be laid, and are typical of the eggs of the species. They were elliptical and are covered with a hard, white shell of fairly coarse, granular structure. They measure as follows (in millimeters): 40 x 28, 42 x 26, 38 x 26, 37 x 22, 36 x 26, 35 x 25, 35 x 26, 40 x 25, 36 x 26; average: 37.6 x 26.1. There are no data on the period of incubation. The smallest specimen which the writer has is an individual with a carapace length of 39 mm, which was caught and sent in from Reelfoot Lake in late September, 1931, and was undoubtedly a very recently hatched individual.

FOOD HABITS.—This species is largely carnivorous in its diet, feeding upon almost any animal matter that is available. From the stomachs of specimens examined in the field the following items have been noted: crayfish, tadpoles, small fish, gastropods, dragonfly nymphs, Corydalis larvae, water beetles, and an assortment of forms obviously picked from the surface, including grasshoppers, crickets, caterpillars, and various dipterous and hymenopterous insects. The scavenger habit is well developed and I have observed the turtles feeding upon dead fish floating at the surface. They do not, however, practice this scavenger habit along the shore. Some vegetable matter is usually present in the digestive system, this representing aquatic sedges, algae, and numerous shallow-water plant species. In Florida, Loennberg (1894) reports that they feed largely upon vegetable matter.

ECONOMIC IMPORTANCE.—*Pseudemys concinna* is far too rare in Illinois to be of any economic importance. To the southward, however, where it is abundant and where it reaches a large size, it is undoubtedly an item of human consumption, though it is not mentioned by Clark and Southall in this connection. Loennberg says that the meat is white and very palatable.

TABLE 16.—MEASUREMENTS OF ILLINOIS SPECIMENS OF *Pseudemys concinna*
(Measurements in millimeters; weight in grams)

Specimen No.	Carapace		Plastron			Tail		Head	Weight	Sex
	Length	Width	Length	Width	Depth	Total	A-T			
1	330	216	293	171	107	61	45	38	3794	♀
2	326	232	300	181	113	55	45	41	3772	♀
3	219	156	194	119	66	87	40	26	966	♂
4	213	153	192	116	67	80	40	25	936	♂
5	75	63	72	47	31	12	10	13	64	Im.

The Pseudemys elegans-troostii Problem

When the writer first began collecting material for this monograph he was rather puzzled at first by the difficulties encountered in obtaining females, eggs, and young of *Pseudemys troostii,* a rather common species in the state. A search of the literature yielded nothing on the life history of the species, and, more confusing still, a search of the larger or more opportunely placed museums failed to unearth any of these specimens. An abundance of material was available from Illinois, and many dozens of specimens passed through the laboratory for study and examination. However, every good example of *troostii* proved to be a male. It was not long, furthermore, before a gradation between males of *troostii* and *elegans* was noted, and an entire and complete series of intergradations between typical *elegans* on the one hand and typical *troostii* on the other was obtained. This series showed the increasing darkening of the carapace toward the *troostii* end, the gradual obliteration of the transverse yellow bar on each costal scute, the increasing amount of dark mottling on the plastron, and the gradual obliteration of the bright red postorbital band on the head through various deepening shades of brown and olive. While this series was being built up, correspondence with Mr. Percy Viosca at New Orleans brought out the fact that he had long believed that *troostii* was merely a melanistic male *elegans.* An opportunity to examine a fine lot of both *elegans* and *troostii* confirmed him in this view, and he published the results of his findings (1933). Knowing, then, of Mr. Viosca's findings, the writer skeletonized his series of *elegans-troostii* intergrades, and made a careful study of the skulls,

leg bones, and vertebrae. The results of this study only confirm the idea that *elegans* and *troostii* are inseparable; he can find no osteological character that will differentiate between them. Therefore, since there are, apparently, no *troostii* females, no *troostii* eggs or young, since a complete intergradation between *elegans* and *troostii* males has been demonstrated, and since there seems to be no anatomical or osteological character upon which they can be separated, he concurs with Mr. Viosca's views. And since *troostii* is the older name (*Emys troostii* Holbrook 1836; *Emys elegans* Wied 1839), *Pseudemys elegans* now becomes a synonym for *Pseudemys troostii,* which is most unfortunate in view of the fact that ex-*troostii* is only the melanistic *male* of the much more familiar ex-*elegans!* Such are, however, the laws of priority. In order to simplify matters and so as not to add unnecessarily to the confusion of names, these melanistic males will be discussed separately at the end of this section.

Pseudemys troostii (Holbrook)

(Red-head; painted turtle; pond terrapin)

(Synonomy for what has heretofore been called *P. elegans*)

Emys troostii Holbrook 1836
Emys elegans Wied 1839
Emys cumberlandensis Holbrook 1842
Emys holbrookii Gray 1855
Emys sanguinolenta Gray 1855
Trachemys elegans Agassiz 1857
Clemmys elegans Strauch 1865
Trachemys holbrookii Gray 1873
Trachemys lineata Gray 1873
Pseudemys elegans Cope 1875
Chrysemys scripta elegans Boulenger 1889
Chrysemys elegans Hay 1892
Pseudemys troostii Viosca 1933

Description.—Shell broad, depressed; uniformly convex both toward the sides and along the anterior-posterior axis, this median axis with but the faintest trace of a keel in the adult if, indeed, any trace is present; if present, this trace is more conspicuous toward the posterior end of the carapace. Carapace emarginate posteriorly, with a notch between the scutes and a second notch within the boundary on the scute at a point about one-third the distance from the posterior margin. These serrations begin faintly on the eighth (occasionally on the seventh) marginal. The vertebral scutes are all of very nearly equal length. The first vertebral approaches a square, being approximately as long as wide, and is slightly urn-shaped. The second, third, fourth, and fifth vertebrals are wider than long, the second and third being the largest of the series, though the fifth is usually almost as wide but is distinctly shorter. The anterior margin of the third and fourth vertebrals is longer than the posterior margin, while the anterior margin of the second and fifth is shorter than the posterior. The costals are large and are arranged in a series decreasing in size posteriorly; the second and third are rectangular, the fourth

approaches the square. The nuchal is triangular, narrow, and usually has a weak median notch. There is a notch near the middle of the border of the first marginal. The marginals flare posterior-laterally beginning with the eighth scute, though the caudal marginals do not flare, carrying out as they do the posterior curvature of the carapace. There is a deep caudal notch. The surface of the carapace is more or less wrinkled, with

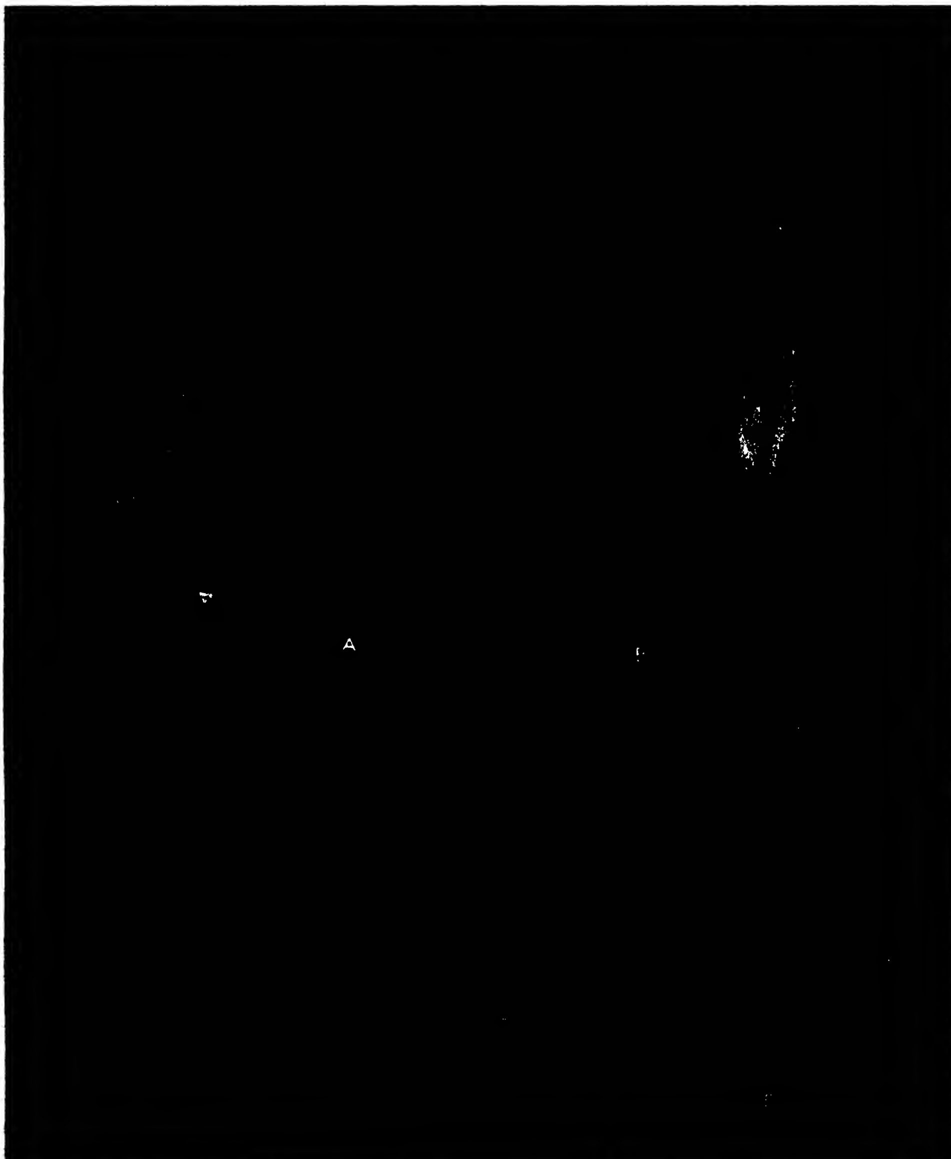


Plate 21.—*Pseudemys troostii: A,* Adult male, ventral view. *B,* Adult female, dorsal view. *C,* Newly hatched young, ventral view. *D,* Newly hatched young, dorsal view. *E,* Adult, lateral view. (This is the form previously known as *Pseudemys elegans.*)

interrupted longitudinal rugae on the costal scutes especially. The conspicuousness of these rugae varies greatly in different specimens. The plastron is very slightly rounded anteriorly, and shows a broad, shallow emargination posteriorly. The posterior lobe of the plastron is narrower than the anterior lobe, and approximately two-thirds the width of the carapace. Gular scutes triangular, the anterior-lateral angle slightly and bluntly protruded. Abdominal scutes longer than wide if the bridge is excluded, and are the longest of the plastral elements, with the longest suture. Interfemoral suture about equalling the interhumeral suture. Anal scutes trapezial, with a long interanal suture. The bridge is wide and rises rapidly and evenly to the marginals. Axillary and inguinal scutes present and well developed, the inguinal the larger of the two. The head is of moderate size, with the snout very short and blunt. The edge of the upper jaw is convex along the posterior margin and there is a shallow but distinct median notch. The tip of the lower jaw curves upward to fit into this notch. Alveolar surface of the upper jaw with a low, very finely serrated ridge. Limbs well developed and the feet fully webbed. There are five claws anteriorly and 4 posteriorly. Tail moderate, projecting beyond the carapace.

Coloration.—The carapace is olive brown, with a complicated pattern of yellow lines and black stripes. On the first two vertebral scutes the lines tend to run longitudinally, becoming irregular and wavy on the posterior scutes. A yellow band of varying width and intensity extends transversely down the middle of the costal scutes, with other bands of black and yellow roughly paralleling it. There are two conspicuous wide black bands on each of these scutes. The marginals, both above and below, show a black spot on the intermarginal sutures, this surrounded by vague concentric circles of yellow and black. The black spot is large and very conspicuous on the ventral side. The plastron is yellow with, typically, a conspicuous black blotch on each scute, and more or less of a black mottling down the mid-ventral suture. Occasionally the plastron is almost entirely black. The bridge often has black spots confluent into a longitudinal band; sometimes this mark is absent. The axillary and inguinal plates are marked with black. The head shows many stripes of yellow or orange, fine dorsally and coarser ventrally and laterally. A very conspicuous blood red or orange red stripe starts at the posterior margin of the eye and extends backward upon the neck, becoming narrow posteriorly, and affords an excellent field mark for the identification of the species. A broad yellow stripe starts under the eye and extends backward along the neck, passing between the tympanum and the jaw, to be met by a stripe from the middle of the jaw at the angle of the mouth. On the under side of the head, a mid-ventral yellow line starts at the mandibular tooth, sending two diverging lines along the neck; a second

broad stripe starts about mid-way between the symphysis and the angle of the jaw and extends toward the stripe starting below the eye, and may or may not reach it. The stripe which in *Pseudemys concinna* starts above the eye and extends to the neck, is missing. The legs are striped with yellow, as is the tail; the fore limbs show two very conspicuous parallel yellow bands on the anterior margin.

YOUNG.—The young show the typical markings and coloration of the non-melanistic adult, but the vertebral keel is high and conspicuous, becoming more and more obscure with advancing age and increasing size of the individual. The concentric nature of the blotches is more pronounced, especially in the marginal and plastral elements. Description of a 30-mm individual: carapace: bright green, all scutes marked with fine parallel black lines arranged either in bands or in concentric figures; also true of the marginals. The yellow stripes of the adult show clearly on the costals; marginals edged with yellow from which edge a yellow mark extends toward the costals, forming a "T." Plastron yellow, each scute with a black spot formed by alternating concentric areas of black and yellow, usually with a light center. Ventral side of the marginals with a similar spot formed by a series of concentric black rings overlapping the intermarginal sutures. Similar spots are on the wings of the abdominals and on both the inguinal and axillary plates in typically marked specimens. Head and soft parts elaborately marked with bands of yellow, green, and black. Of these the most conspicuous is a Y-shaped band starting ventro-laterally on the neck and forking behind and below the mouth, one arm terminating at the margin of the lower jaw. A second Y-shaped band starts at the symphysis of the lower jaw, forking almost at once to send the arms of the "Y" down the ventral side of the neck. The crimson area behind the orbit is fully developed and conspicuous, blending into a pale green stripe which runs back along the side of the neck. Limbs and tail green, streaked with bright yellow.

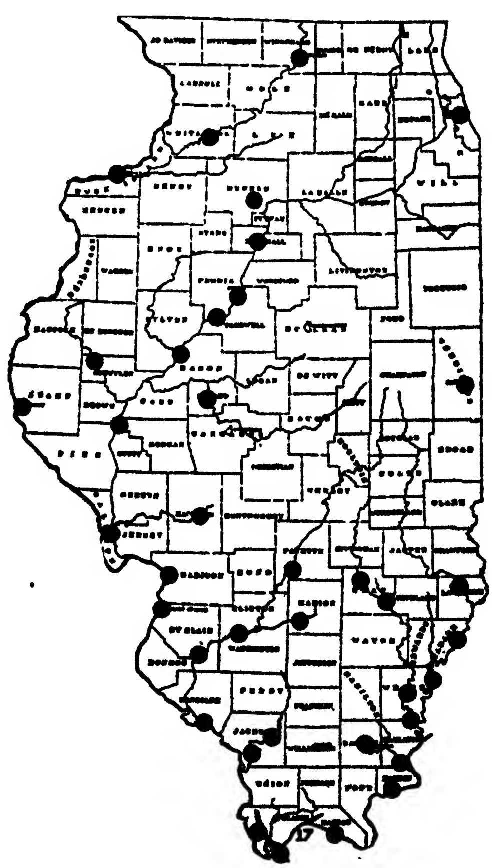
SEX DIFFERENTIATION.—The tail is much longer in the female than in the male. In the female the anal opening lies beyond the posterior edge of the carapace, while in the male this opening lies below the carapace. The red band of the male is likely to be brighter than that of the female, especially in the early spring and during the breeding season. The claws of the front feet of males are very long, slender, curved; those of the female are short and stout, and hence more practical for digging the nest.

GEOGRAPHIC DISTRIBUTION.—*Pseudemys troostii* is distributed over the lower two-thirds of the Mississippi Valley, from northern Illinois, Indiana, and Ohio southward to the Gulf of Mexico. It is not listed as occurring in Ohio by Smith (1882), or by Morse (1904), though that state is included within the range of the species by Stejneger and Barbour (1923). It is not recorded from Michigan by Ruthven *et al* (1928).

PLATE 22.—*Pseudemys troostii: (Above)*—Sex differentiation as illustrated by the claws of the fore feet—*left,* female; *right,* male. *(Below)*—Variations in plastral markings of melanistic males; *left,* markings nearly typical of the non-melanistic individuals; *right,* practically the extreme exhibited in melanistic individuals.

Hay (1892) reports it from Indiana, but very sparingly; it is recorded from Vigo County, Indiana, by Blatchley, and Evermann and Clark (1920) report it as the rarest turtle in Lake Maxinkuckee. It has not been recorded from Wisconsin, though it occurs in Illinois very close to the Wisconsin line, so that the writer might venture a guess that it might be found in Lake Koshkonong. Blanchard (1922) records it from western Tennessee, and the writer has found it very abundant in Reelfoot Lake in that region. It is one of the commonest turtles of Louisiana (Beyer, 1899), but apparently does not extend far eastward. Haltom (1931) reports it for but one region in Alabama. Strecker (1915) reports it from the entire length and width of Texas; Hurter and Strecker (1909) have one record from northeastern Arkansas, and Hurter (1911) has numerous records from Missouri. Yarrow (1882) records it from Mexico, Kansas, Tennessee, Louisiana, Missouri, and from the Yellowstone River; his report of the species from South Carolina is based on a specimen of *Pseudemys scabra.*

Illinois Records.—For Illinois, the species is reported as from the southern part of the state by Davis and Rice (1883). For the Quincy region, Garman (1888) records it as frequent in sloughs; in his later report (1892) he records it from the larger streams in the southern two-thirds of the state, and gives Quincy, Henry, Peoria, Pekin, Havana, and Mt. Carmel as specific localities. Hurter (1911) reports it from St. Clair and Madison counties, and Hay (1893) from Mt. Carmel. The Field Museum has specimens from Liverpool, Maeys, Olive Branch, and Mt. Carmel. The writer has examined specimens from the following localities: Havana, Chester, Meredosia, Danville, Sterling, Carlysle, Louisville, Cairo, Horseshoe Lake in Alexander County, Camden, Mt. Carmel, Peoria, Quincy, Shawneetown, Metropolis, New Haven, Carmi, Clay City, Lawrenceville,



Map 17.—*Pseudemys troostii.*

Centralia, Murphysboro, DeSoto, New Athens, Vandalia, Carlinville, Hardin, Bureau, Harrisburg, and Petersburg. The turtle is common in the Illinois River, increasingly so toward the south, and is much more adundant in the southern part of the state than in the northern portion.

HABITAT.—*Pseudemys troostii* is found most commonly in large, quiet waters, and only rarely in fast water. Thus it is an abundant species in the wide reaches of the larger rivers of the state—the Mississippi and Illinois—as well as in the over-flow lakes along the Mississippi and Illinois bottoms. Toward the headwaters of the various rivers in which it occurs, the species becomes increasingly rare, and never does it reach beyond the region where the rivers are wide and slow-flowing. Soft bottom, such as silt or mud, seems to be the most congenial, and a considerable growth of aquatic vegetation is highly desired by the turtles. In the spring, when the larger streams grow into flood conditions, if the turtles are out of hibernation they escape the turbulent conditions of mid-stream, and enter the flooded bays and ponds, where they remain until the recession of the water drives them back to the river. Those ponds which are permanent will likely have a permanent *troostii* population. Again, it is more of a pond than a river species; hence the local name of "pond terrapin."

HABITS.—Distinctly aquatic in its habits, *Pseudemys troostii* is seldom found on land except during the nesting season or when traveling from pond to pond or from pond to river. It is a quick, active species, which indeed is very much at home in the water, though its movements are not as rapid as those of the soft-shelled turtles or, for that matter, as the turtles of the genus Chrysemys. This is probably due to the bulk and weight of the shell. If great beds of aquatic vegetation are available, the turtles wander around, in and out, among the thickest of the growth, their perambulations often wearing open pathways or tunnels through it. As a result of their selection of quiet, vegetated regions they are, like turtles of the genus Chrysemys, frequently found with dense growths of algae on the carapace, and little growths of the colonial protozoan *Epistylis articulata* are often found upon the plastron. If logs are available out in mid-stream, the turtles pile up on them two and three deep, and spend the hotter hours of the mid-summer days sunning themselves in the security of their island retreat. If logs are not available, their heads may be seen poked out above the surface, just beneath which the turtles lie at rest for long periods at a time, apparently quite as relaxed as if they were upon a more secure footing. Always watchful, the least sign of anything dangerous sends them below the surface like a flash, and once frightened, they are more cautious than ever. Refuge is sought at once in the heart of the densest of the vegetation, to the very bottom of which they burrow immediately, remaining motionless until the fright

reaction wears off. The sloping bank of the water's edge is seldom utilized and one rarely sees a turtle of this species basking in such a location. If cornered on land, the turtle withdraws completely within its shell, the withdrawal of the head being accompanied by a hissing sound as the air is expelled from the lungs to accommodate the incoming bulk of the head and neck. If bothered too much, it shows a reluctant inclination to snap, a sort of half-hearted attempt that is but a poor offense at best. In captivity it refuses to eat for a week or two after its capture and is very timid, but once it becomes used to its surroundings, it grows very tame and will eat from the hand offering food, and follow it all over the aquarium. Agassiz (1857) reports that he has heard turtles of this species "emit a piping note." The writer was astonished one night to hear a distinctly whistled note arise from one of his turtle pens, repeated over and over again at irregular intervals. Quiet watching finally located the sound as coming from a half-grown turtle of this species, which periodically raised its head to the fullest extent of the neck and then "whistled," the note coming as the air was expelled from the lungs. For three days the turtle "whistled," and then suddenly died. Dissection showed a small foreign obstruction lodged in the trachea, and the writer was able to reproduce the whistled note by blowing through the trachea with a blow pipe.

Nesting Habits.—*Pseudemys troostii* nests in clear sandy areas not far removed from the water. The egg laying usually begins during the third or fourth week of June and is completed by the end of the first week of July. While there is considerable variation in the time of day at which nest digging and oviposition occurs, by far the greater number lay early in the morning, while a few lay late in the afternoon; it is rare to find this turtle laying during the day between eight in the morning and four in the afternoon. The female leaves the water slowly and cautiously; one glance at her will show that she has something quite definite on her mind even though she wanders up the bank in a leisurely, casual manner, her head well out, looking from side to side with considerable care. Now and again she pauses to scratch prospectively, but not being satisfied with the soil conditions, she goes on until she finds exactly the right spot. Here she begins to dig, using the hind feet in the process, the front feet remaining more or less fixed in their position. She digs steadily, throwing the loosened sand out behind her, pausing now and again to stare fixedly at some suspicious object she had not noticed before. The digging is not hurried, but gives one the impression of determination rather than haste. The hole is dug to a depth of between four and six inches, depending upon the ground conditions and the size of the turtle, and requires approximately thirty minutes for completion. The eggs are deposited one at a time as soon as the nest is finished, and

are laid at the rate of one about every 40 seconds until the complement is complete. If the female is disturbed while laying she usually shows no offensive reaction, but retires passively into her shell and waits. It takes considerable disturbance and actual physical violence to cause her to forsake the hole while the laying is in progress, but the actual oviposition is suspended without great cause. When the last egg has been deposited, the dirt is raked into the hole and the eggs covered even with the surface, the hind legs dragging in the sand scattered during the digging process. With the location of the nest thus concealed, the turtle returns directly to the water, usually at a greater speed than she showed on leaving it. From an examination of the ovaries it has been ascertained that females become sexually mature and lay for the first time when they attain a carapace length of 7 to 7½ inches.

EGGS.—The eggs of this turtle are oval, with well and equally rounded ends, white, and of a rather coarse and granular shell texture. The number varies considerably, depending upon the size and age of the turtle. A large complement contains 20 eggs, and I once found a set containing 23. The average number of eggs is between 15 and 18, and small clutches of 6 or 8 eggs usually represent the first efforts of a young female. In size they average 37 x 22 mm, varying from 34 x 21 mm to 38.5 x 23.5 mm; these figures are from seven different sets of eggs taken at Meredosia, numbering 121 eggs. Great numbers of nests of this turtle are found dug out, the old eggshells giving mute evidence of the activity of raccoons and skunks, which animals delight in turtle eggs. In the vicinity of Meredosia, on the Illinois River, the young hatch toward the end of August or early in September. Immediately after hatching they go directly to the nearest water and remain in the vegetation-choked shallows.

FOOD.—*Pseudemys troostii* is largely a carnivorous species, but is able to subsist for long periods on a strictly vegetable diet, as the writer has shown in the laboratory. In nature the food consists of tadpoles, crayfish, mollusks (mostly gastropods), the larger larvae and nymphs of aquatic insects, and small fish, of which the following species have been identified: *Notropis hudsonius selene, Umbra limi, Apomotis cyanellus, Helioperca macrochira,* and *Perca flavescens.* Usually a quantity of well-masticated vegetable matter is to be found in the digestive system, this consisting of the various aquatic plants of the region apparently without much discrimination as to species. In the laboratory it will eat chopped meat with avidity, and will also subsist on lettuce, apples, and to some extent on bananas. It has a strong scavenger tendency, and will be found feeding upon dead fish, amphibia, and even small mammals which find a watery grave. It will not, however, leave the water to feed upon dead matter upon the shore.

Economic Importance.—The three most important "food" turtles outside of the snapper (Chelydra) and the soft-shells (Amyda) are: *Pseudemys troostii, Graptemys geographica,* and *Graptemys pseudogeographica pseudogeographica.* Of these, *troostii* is the most common, but since it does not attain a size equal to that of the snapping turtle or the soft-shelled species, it is not used extensively for table purposes. However, Clark and Southall (1920) report that *troostii* (i.e. *elegans* of these writers) appears commonly in the fish markets of Chicago, and they are sometimes shipped as far as Philadelphia and Washington from the Illinois River. The price of these turtles now ranges around 20 cents each. The meat is of high quality and delicious flavor.

Table 17.—Measurements of Illinois Specimens of *Pseudemys troostii*
(Measurements in millimeters; weight in grams)

Specimen No.	Carapace		Plastron			Head	Tail		Weight	Sex
	Length	Width	Length	Width	Depth		Total	A-T		
1	243	181	206	147	95	36	68	40	2035	♀
2	233	178	216	147	94	35	54	35	2050	♀
3	230	175	224	139	88	37	53	33	2006	♀
4	215	159	199	130	87	31	40	33	1320	♀
5	200	154	185	120	73	28	73	38	1005	♀
6	196	145	188	109	76	31	50	40	1083	♂
7	195	152	186	120	72	28	50	39	1094	♂
8	192	151	184	126	73	28	50	36	1021	♀
9	189	154	178	78	65	27	50	.	996	♀
10	185	131	168	95	60	26	60	40	740	♀
11	170	132	157	100	58	25	70	34	637	♂
12	166	129	161	117	58	24	55	34	644	♀
13	156	122	151	100	55	25	46	..	545	♂
14	112	92	103	74	44	20	43	30	223	♂
15	110	85	102	66	40	19	30	..	185	♀
16	86	75	81	57	32	16	27	..	101	♂

Parasites.—This turtle, being an abundant species, is a good form for a study of turtle parasites, and affords a good collecting subject for class study in parasitology as it usually is rather heavily infested with a variety of forms. The writer has taken the following from this species: *Neoechinorhynchos emydis* (Acanthocephala), *Allassostoma magnum* and *Polystomoides microcotyle* (Trematoda), and *Ophiotaenia testudo* (Cestoda), this being the second record of this Magath species.

Melanistic Males of Pseudemys troostii

(Black-headed turtle)

(Synonomy of what has heretofore been called *Pseudemys troostii*)

Emys troostii Holbrook 1836
Trachemys troostii Agassiz 1857
Pseudemys troostii Cope 1875
Chrysemys troostii Boulenger 1889

Description.—These melanistic males, representing what, in the literature of herpetology to date, has been the original *Pseudemys troostii*, show the physical and structural characteristics of scute conformation as already described for the non-melanistic forms, and hence

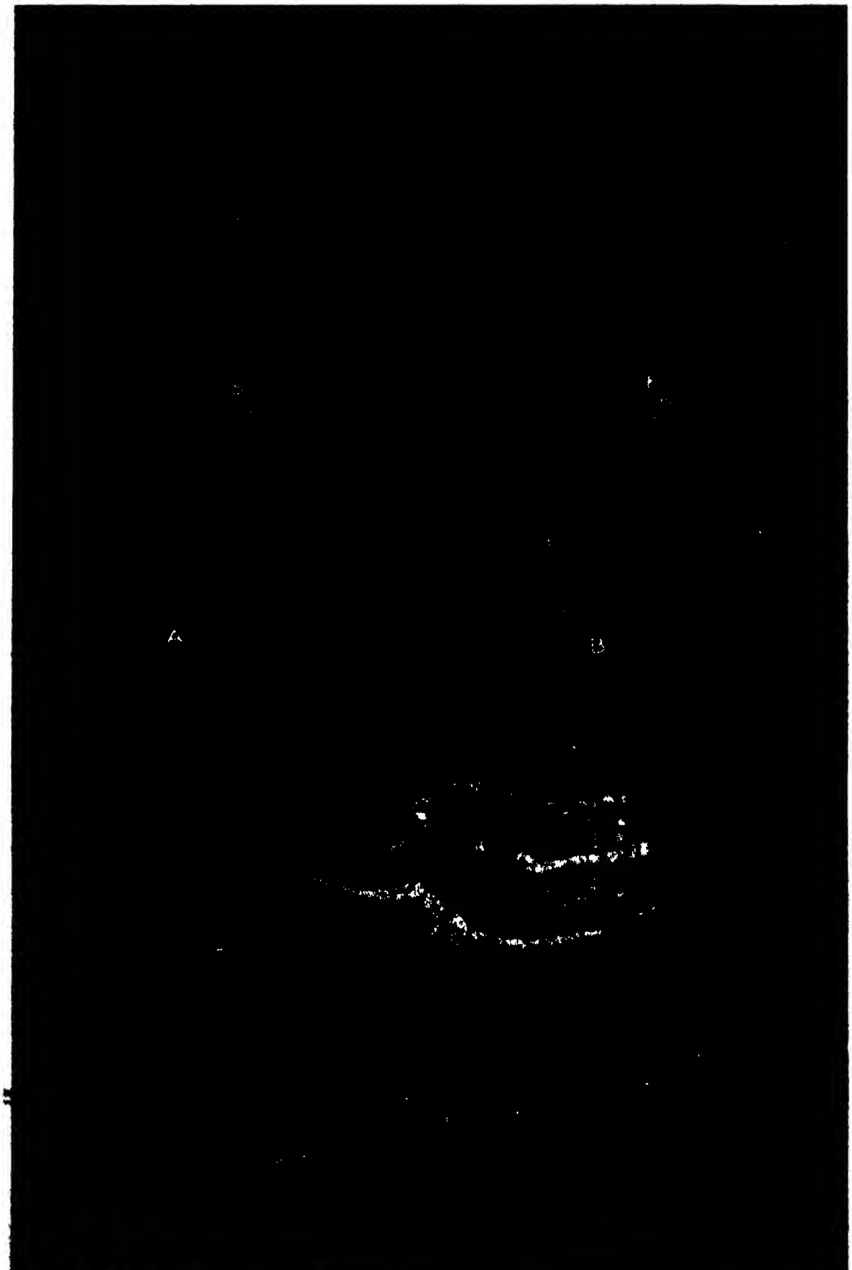


Plate 23.—*Pseudemys troostii*, melanistic males: *A*, typical adult with a smooth carapace. *B*, Adult; shell with many fine rugae. *C*, Head study of a typical adult non-melanistic male. *D*, Head study of a typical adult melanistic male.

need not be repeated. There is but one feature which, while not at all constant, appears much more frequently in these turtles than in the typically colored forms; this is a rugous condition of the dorsal scutes, especially of the costals. These small ridges tend to follow the general outline of the carapace, and in extreme development may be a highly conspicuous characteristic of the specimen; again, they may be absent.

Coloration.—Carapace: dark olive to dark grayish brown, without any trace of light color markings. The sutures between most (if not all) of the scutes of the carapace are covered with black or very dark chocolate brown in an irregular pattern. The olive green ground color is often brightest on the three anterior marginals; on the ventral surface of the marginals, yellow replaces the olive green. In a fully melanistic specimen the entire carapace has the appearance of being dull and indefinite as to color markings. The plastron is pale yellow or straw, with a varying amount of black markings. On the anterior two-thirds of the plastron these black markings appear as streaks which follow the sutures for the most part, with the dark central area expanding posteriorly so as to cover most of the surface of the femorals and anals. In many cases one can observe traces of the last vestiges of the dark blotches so characteristic of the plastron of non-melanistic individuals. Occasionally there are black lateral patches on the abdominals. The bridge shows black patches along the sutures. The under side of the marginals shows a black patch or spot, the center of each spot falling upon a suture; hence a yellow bar reaching to the margin of each marginal scute, this representing the ground color. Head, neck, and limbs of the same dead tone as the carapace, the head olive green, finely and inconspicuously striped with black. An inconspicuous dark olive-brown band extends backward from the posterior margin of the eye, replacing the brilliant red band of the typical non-melanistic individuals. Behind the eye it widens, to reach its maximum width dorsal and posterior to the ear, beyond which it again becomes narrow. The jaws are dark, spotted and lined with black. A short median stripe of yellow begins at the symphysis of the lower jaw and branches at once to send two conspicuous stripes down the under surface of the neck. The angle of the jaw lies between two brown bands, one arising from the posterior median margin of the orbit, the other arising from near the posterior lateral margin of the lower jaw. These bands unite posterior and ventral to the ear and extend as a single inconspicuous line down the neck. Both limbs and tail show only very faint color markings; the tail tends to exhibit a yellowish lateral stripe and a median dorsal brown stripe. All variations between the brightly colored typical individuals and the very dark, fully melanistic individuals may be found, but only in the males of the species.

While dealing with the question of coloration, it is interesting to note

TABLE 18.—GEOGRAPHIC DISTRIBUTION OF P. "ELEGANS" AND P. "TROOSTII"

State	Authority	P. "elegans"	P. "troostii"
Wisconsin	Pope, Dickinson	No	No
Ohio	Morse	No	No
	Stejneger, Barbour	Yes	No
Indiana	Hay (1893)	Rare	Rare: 1 record
	Blatchley	Rare	No
	Evermann, Clark	Rarest species	No
Tennessee	Blanchard (1922)	Western: very common	No (?)
	Cahn	Reelfoot: abundant	Common
Louisiana	Beyer	Abundant	Common
Alabama	Haltom	Present	No
Texas	Strecker	Statewide: common	Southeast: 1 record
Arkansas	Hurter, Strecker	Northeastern	Northeast: 1 record
Missouri	Hurter	Common	Common
	Blanchard (1924)	Southeastern	No
Kansas	Yarrow	1 record	No
Oklahoma	Ortenburger, Freeman	Scattered	No
Illinois	Garman (1892)	Common: southern ⅔	Very rare

what Hay (1892) has to say: "This is a very beautiful and a characteristically marked species. It may readily be distinguished from *C. elegans* by the brown borders of all the scutes, and the absence of yellow stripes on the carapace. Both have a blood-red stripe along the neck." It is obvious from this last sentence that Hay either did not have fully melanistic "troostii" or that he has made a composite description from several specimens; for the melanistic form, when fully developed so as to have lost all trace of the transverse yellow costal bars, does not have the blood-red stripe behind the eye, which stripe is characteristic only of "elegans."

DISTRIBUTION.—In order to bring out more conveniently the geographic distribution of the melanistic males as compared to the non-melanistic individuals, as revealed in the published literature, the writer wishes to revert for the purpose of this discussion only, to the old nomenclature used in this literature in which the melanistic form is treated as a distinct species, by calling the non-melanistic forms "elegans" and the melanistic males "troostii." A comparison of the distribution of these two forms is most easily made according to states as shown in Table 18. As to the distribution within Illinois, a glance at the two maps, showing the distribution of *Pseudemys troostii* (Map 17) and of the melanistic males (Map 18), will show that these melanistic individuals are more common in the southern part of the state than in the northern.

MAP 18.—*Pseudemys troostii*—melanistic males.

From the foregoing information, certain generalized statements may be drawn, though until a more systematic and careful series of collections is made throughout the Mississippi Valley we cannot delimit with any exactness the range of these melanistic *troostii*. It is fairly obvious, however, that where "elegans" is common, there, too, we find "troostii"; (how Blanchard missed it around Reelfoot Lake, Tennessee, is a puzzle,

for here it is a very common species); that at no place is it as common as "elegans," which is perhaps not surprising, as only one sex is involved; that it is not found outside of the range of "elegans"; and that it is much more common in the southern part of the Mississippi Valley than elsewhere. Since it is not found throughout the range of "elegans," and since it *is* found most abundantly in the southern part of the range of that form, are we to infer that there is a temperature factor involved in the production of these melanistic individuals? Although we cannot say for certain that all adult male "elegans" *do not* become melanistic in old age, this would seem to be the case. A series of measurements made on both "elegans" males and "troostii" follows. Carapace length in mm:

"troostii": 217, 212, 210, 202, 200, 196, 193, 191, 177, 172.
"elegans": 196, 195, 192, 189, 185, 180, 166, 156, 112, 110, 86.

The writer has found no example of melanistic "troostii" smaller than 172 mm, which might be considered as typical of the form, though intermediate, intergrading forms with "elegans" characters still visible have frequently been found below this size. Nor has he found any male "elegans" that equals in size the largest of the "troostii." This might lead one to infer that "troostii' is the very old male "elegans," but such a statement is not permissible until a further study has been made, for the largest "elegans," measuring well up into the "troostii" series, show no signs of any melanistic tendency.

So far as habitat selection is concerned, the melanistic "troostii" are always associated with the non-melanistic individuals: both are caught in the same net at the same time, though, as we have said, in fewer numbers. In only one point of behavior could one note anything like a characteristic not pronounced in both. The non-melanistic "elegans" is a rather quiet, inoffensive, peaceful species, not given especially to snapping or pugnacious qualities in either sex; the melanistic "troostii," on the other hand, frequently exhibits decided pugnacity.

TABLE 19.—MEASUREMENTS OF ILLINOIS SPECIMENS OF MELANISTIC MALES OF *Pseudemys troostii*
(Measurements in millimeters; weight in grams)

Specimen No.	Carapace		Plastron			Head	Tail		Weight
	Length	Width	Length	Width	Depth		Total	A-T	
1	217	155	193	113	70	29	65	45	1214
2	212	151	188	117	72	28	75	39	1190
3	202	147	185	114	63	28	75	42	1039
4	200	146	186	112	69	27	66	41	1002
5	191	148	171	81	66	28	70	40	965
6	177	143	161	80	62	27	70	41	872
7	172	126	152	91	55	26	72	39	720

FAMILY TRIONYCHIDAE

Trionycidae Gray 1825	Trionychida Strauch 1862
Trionychidae Bell 1828	Chitradae Gray 1870
Steganopodes (part) Wagler 1830	Emydinadae Gray 1870
Potamites Duméril & Bibron 1835	

External Features.—Body extremely flattened, nearly circular in outline, both carapace and plastron without any epidermal skeleton composed of scutes, the dermal skeleton covered with a continuous leathery skin which is somewhat cartilaginous along the margin. Snout projected into a flexible fleshy proboscis, with terminal nostrils. Jaws partially concealed beneath fleshy lips; the ear is hidden. Head and neck completely retractile within the shell along a sigmoid curve. Digits 5-5, claws 3-3, only the three inner digits with claws, the unclawed digits concealed within the web.

Osteological Features.—Dermal skeleton not completely ossified. Epiplastra separated from the hyoplastra by a T-shaped entoplastron; marginal bones absent or at best forming only an incomplete series, not connected by ribs. Cervical vertebrae without transverse processes; the articulation between the last cervical and first dorsal vertebrae by the zygopophyses only. Mandible with articulary concavities. The outer border of the tympanic cavity is notched. Pterygoids not narrowed posteriorly and separated from each other. Basisphenoid joining the palatines. Pelvis is not anchylosed to the carapace or to the plastron.

Genus Amyda Oken

Amyda Oken 1816	Callinia Gray 1869
Aspidonectes Wagler 1830	Isola Gray 1873
Gymnopus Duméril & Bibron 1835	Oscaria Gray 1873
Platypeltis Fitzinger 1835	Nilssonia Gray 1873
Pelodiscus Fitzinger 1835	Ida Gray 1873
Potamochelys Fitzinger 1843	Yuen Heude 1880
Chitra Gray 1844	Psilognathus Heude 1880
Tyrse Gray 1844	Temnognathus Heude 1880
Trionyx Gray 1844	Gomphopelta Heude 1880
Dogania Gray 1855	Coelognathus Heude 1880
Rafetus Gray 1864	Tortisternum Heude 1880
Aspilus Gray 1864	Ceramopelta Heude 1880
Pelochelys Gray 1864	Coptopelta Heude 1880
Landemania Gray 1869	Cinctisternum Heude 1880
Sarbieria Gray 1869	Aspidertes Hay 1903
Fordia Gray 1869	

External Features.—Body extremely depressed, nearly circular in outline. Carapace and plastron without epidermal scutes and covered by a continuous thick, leathery skin which is somewhat cartilaginous at the flexible margins of the carapace. Head long and pointed, with a

tubular snout prolonged into a fleshy proboscis with nostrils terminal. Fleshy lips concealing the horny coverings of the jaws. The ear is completely hidden. Head and neck completely retractile within the shell; limbs exposed. Feet large; digits 5-5; claws 3-3, the fourth and fifth digits clawless.

Osteological Characters.—Carapace not completely ossified. Outer extremities of the nuchal plate overlie the second dorsal rib; the neural plates are well developed. The hypoplastron is distinct from the hyoplastron. Plastron with not more than five callosities. Bony choanae between the orbits; postorbital arch narrower than the diameter of the orbit. Posterior border of the pterygoids free and without an ascending process.

Amyda mutica (LeSueur)

(Spineless soft-shell; queen turtle; leatherback; soft-shell)

Trionyx muticus LeSueur 1827
Gymnopus muticus Duméril & Bibron 1835
Amyda mutica Agassiz 1857
Potamochelys microcephala Gray 1864
Callinia microcephala Gray 1869
Aspidonectes muticus Baur 1888

Description.—Body greatly depressed, broadly oval approaching circular in outline, covered with a thick, leathery skin and without scales, the carapace flexible at the margins, being largely cartilaginous. Carapace smooth, occasionally slightly granular. Anterior margin smooth, without a trace of the row of tubercles which adorn this region in *A. spinifera,* and other North American members of the genus. The edge of the carapace is entire, without serrations. The plastron is placed anterior, leaving the posterior limbs exposed and non-retractible within the shell. Like the carapace, the plastron is largely cartilaginous. The entoplastron has a single callosity, the epiplastra each a small callosity, these being best developed in the adult, and better developed in males than in females. The head is small, slender, long and pointed, sloping rapidly anterior to the eyes into a short, fleshy proboscis. This proboscis terminates obliquely, so that the nostrils, while terminal, tend to be somewhat inferior in position; they are circular and show no trace of a ridge projecting into them from the side of the septum. The margins of the jaws are slightly concave; the horny covering of the upper jaw has a keen cutting edge which is deepest toward the anterior symphysis and bluntly toothed toward the posterior articulation. Lower jaw with a sharp cutting edge, and both jaws with a narrow alveolar surface. The horny covering of the jaws is at least partially concealed beneath the fleshy lips. The limbs are well developed, strong; the feet are fully webbed with both marginal and interdigital webbing. The anterior limbs have a few transverse scales on their dorsal surface, and the posterior

limbs usually have a single larger scale. Digits 5-5, the claws 3-3, the two outer digits being concealed in the web and being without claws. Tail strong, conical, fleshy, pointed.

COLORATION.—The dorsal surface of the carapace, head, neck, and limbs are brown to olive-brown. The carapace may be unicolored or marked with small, obscure blackish spots or blotches, and short, slender

PLATE 24.—*Amyda mutica: A,* Adult female, ventral view. *B,* Adult female, dorsal view. *C,* Newly hatched young, dorsal view. *D,* Adult, lateral view. *E,* Head study of an adult.

lines. There is a light, yellowish margin to the carapace, this preceded mesially by a black line. These markings vary considerably both with the individual and with the age of the specimen, becoming obscure in fully adult animals. The plastron is pearly white, somewhat translu-scent; the under sides of the head, neck, and limbs are whitish and are unmarked. Soles of the feet bluish gray, unmottled. A pale, black-bordered stripe extends from the snout to the eye, posterior to which it is continued along the sides of the neck.

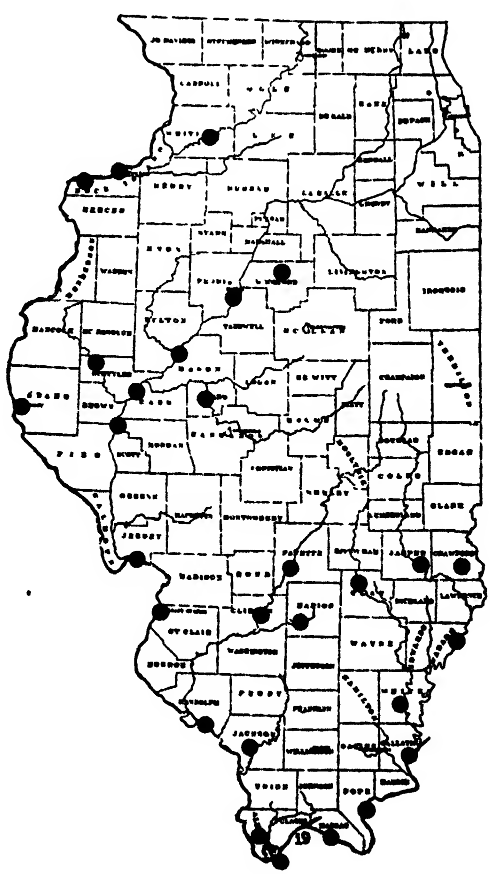
YOUNG.—The young resemble the adult in all structural features, but differ considerably from them in color pattern. The most frequent coloration shows the carapace sprinkled with many fine, bacilliform dashes of darker brown on the otherwise unicolored carapace. The lateral and posterior margin of the carapace is bordered with yellow, this preceded by a black mesial line. With age these bacilliform markings seem to spread and tend to become amoeboid in shape and finally either become obscure or disappear entirely.

SEX DIFFERENTIATION.—The tail of the male is much longer than that of the female, and projects farther beyond the edge of the carapace. The callosities of the male are somewhat more pronounced than are those of the female. The female usually has long claws on the hind feet, the male long claws on the fore feet. Fully adult males are much smaller than similar females.

GEOGRAPHIC DISTRIBUTION.—*Amyda mutica* is found to range from the St. Lawrence River southward to Florida, and westward through the plains. From the north it is reported by Nash (1906) as very rare for the Ontario side of Lake Erie. It is recorded in the fauna of Pennsylvania by Surface (1908) because of this record of Nash, but no locality records are given for that state; it is not listed for New England by Babcock (1919). Morse (1904) states definitely that it has not been found in Ohio, though Smith (1882) records it from Lake Erie and from the Ohio River, which agrees with the range given by Davis and Rice (1883) as "north of the Ohio River." Blatchley (1891) reports it from Western Indiana, and Hay (1892) has records extending from northwestern to southeastern Indiana, though Evermann and Clark (1920) do not record it in Lake Maxinkuckee. The type was collected from the Wabash River at New Harmony, Indiana, about due east of Carmi, Illinois. Ruthven *et al* (1928) do not report its occurrence in Michigan. For Wisconsin it is reported from the western half of the state by Higley (1889), who says it is more common there than is *A. spinifera*. Hoy (1883) had previously reported it from "all the tributaries of the Mississippi River." In contradistinction to this, Pope and Dickinson (1928) refer to the meager records of the species in the state

as indicating its presence is "rather unusual." Over (1923) reports it from the Missouri River in South Dakota, but as an uncommon species. Burt (1927) records it from northeastern Kansas. Hurter (1911) reports it from the rivers in Missouri, and Hurter and Strecker (1909) mention it from Arkansas, as does Yarrow (1882) who adds a questionable Florida record. Blanchard (1922) reports it from western Tennessee, and the writer has taken many specimens from Reelfoot Lake in that region. Halton (1931) does not record it for Alabama, and it is not reported from Texas. Ortenburger and Freeman (1930) report it from western Oklahoma.

Illinois Records.—Yarrow (1882) has several records of *Amyda mutica* from Mt. Carmel, Illinois, collected by Ridgway, and an "Illinois" record of Kennicott. Davis and Rice (1883) record it from the Mississippi and "other rivers of the state." For the region about Quincy, Garman (1888) says that *A. mutica* is abundant in the Mississippi River, and less abundant in the sloughs. In his later report (1892) covering the state, he reports it from running water throughout the state, with specific records from Mackinaw Creek in Woodford County, Peoria, Quincy, Mt. Carmel (the Wabash River; this is close to the type locality, New Harmony, Indiana), and from the Ohio River at Cairo. Hurter (1911) does not report it from the Illinois side of the Mississippi. Muller (1921) reports it from Illinois, across the Mississippi River from Freeport, Iowa, and records its breeding there. The Field Museum has specimens from Meredosia and from Golconda. The writer has examined specimens from the following localities: Rock Island, Meredosia, Havana, Crooked Creek in Schuyler County, Robinson, Shawneetown, Carmi, Horseshoe Lake in Alexander County, Chester, Murphysboro, Centralia, Grafton, Carlysle, Vandalia, Louisville, Newton, Beardstown, Petersburg, Sterling, and East St. Louis.



Map 19.—*Amyda mutica*.

Habitat.—The spineless soft-shelled turtle apparently is quite typical of rivers and streams in general, irrespective of their size, providing these afford a clear bottom of sand or silt. Rock areas are distinctly avoided, as are stagnant ponds and overflow areas. Vegetation does not attract this turtle as it does most of the hard-shelled species. Current means little that is disadvantageous to it, for the great paddle-like feet are powerful enough to drive the turtle against a considerable current. Since *Amyda mutica* prefers running water, it is found more often in rivers than in lakes.

Habits.—As is the case with all of the soft-shelled turtles, *A. mutica* is highly aquatic; it is even more aquatic than *A. spinifera* for it almost never leaves the water and but seldom climbs up on logs to bask in the sunshine. On land it seems to feel clumsy and awkward (which in reality it is not), and hence never goes far from the edge of the water, excepting perhaps at the breeding season. If one would search for this turtle one should seek a river with clear water, considerable current, and a sandy bottom free from rocks and plant growth. In such a stream there are likely to be windfalls and piles of half-submerged drift-wood along the shores, or perhaps a tree lying half on the shore and half in the water. About such places one is most likely to encounter *A. mutica,* for it browses around, as it were, among the tangle of brush, seeking food amid the partial concealment of the branches of the drift. During the warmest days of mid-summer, these turtles sometimes come to the water's edge, and lie upon the flat bank a few inches from the water, as if afraid to adventure further inland. Here they bask in the sun, legs drawn up under the cover of the drooping edge of the carapace, instantly ready for the necessary scramble back into the water. The neck is usually protruded to the fullest extent, and lies flat on the ground, the turtle being fully relaxed. But even though relaxed, the ever-watchful eye is never closed, and the turtle is constantly alert for possible dangers. If anything suspicious occurs, there is a frantic scramble for the water, the claws digging into the soft ground for firmer hold. The progression appears awkward, but is surprisingly swift for an animal whose legs are so far apart and set so nearly parallel to the ground. Over a level, unobstructed sand beach one of these turtles can outrun a man. Once they hit the water they disappear beneath the surface with a swirl like that made by a fish, as the powerful strokes of their propellers begin to get in their action. These feet are not only very large but are fully webbed, as in all of the members of the genus, and give the turtle great speed under water.

When at rest under water, the turtles select a shallow-water environment, free from any vegetation, and here in the sandy bottom they proceed to bury themselves. This is done by flipping up the loose sand and permitting it to settle down again upon the carapace, until the entire

shell is buried from sight and only the head is out. This head, being colored so nearly like the sand, is almost invisible. Thus concealed, the turtles lie motionless for hours at a time, being able to obtain sufficient oxygen for respiration from the water through their pharyngeal method of respiration (as will be mentioned in the section dealing with the closely related *A. spinifera*, p. 190). The writer has repeatedly demonstrated this pharyngeal respiration in *Amyda mutica* in the laboratory by inserting grains of carmine in the water close to the nostrils and observing their sudden dive into the nasal passage as the hyoid apparatus drops. A similar phenomenon has also been demonstrated about the anus, indicating that there is an anal respiration associated with the posterior wall of the gut. Some such accessory respiratory mechanism is certainly of great advantage to a highly aquatic species of air-breathing animal, for the rigid construction of the shell of turtles offers no opportunity for excessive lung expansion or of air storage. Agassiz (1857) long ago measured the lung capacity of turtles in relation to their weight and in association with their habits. He found that in *Amyda ferox*, which is as aquatic as *mutica*, the lung capacity was to the body weight as 1:17; in *Cinosternon pennsylvanicum* (*K. subrubrum*), also exceedingly aquatic, it was as 1:16; in *Cistudo* (*Terrapene*) *triunguis*, highly terrestrial, it was almost as 1:1. Hence it would seem that the aquatic turtles have proportionately much less lung capacity than terrestrial species. The highly vascular development of the mucous lining of these regions, then, enables the turtles to remain under water for long periods, and explains their ability to remain so long submerged. It also makes clear the method of respiration during the long periods of hibernation (and perhaps also of aestivation in some species). The writer has demonstrated a similar pharyngeal respiration for various hard-shelled turtles as well (Chrysemys, Pseudemys, Sternotherus), and finds that the rate of pharyngeal movement increases as the temperature of the water rises. While lying, then, concealed in the sand of the river bottom, the turtles are able to obtain a sufficient oxygen supply without coming to the surface. If they desire more air, they extend their necks upward until the nostrils break the surface of the water; hence the selection of a shallow-water burial place. This pharyngeal and anal respiration is, however, insufficient for the turtles if they are active, which explains why soft-shelled turtles die so readily when caught in nets.

Amyda mutica is an expert swimmer. Very fast, it is able to capture fish with ease, its very extensible neck giving it a great advantage in this regard. In a large tank I once watched this turtle capture a small brook trout (*Salvelinus fontinalis fontinalis*), one of the fastest and most agile of our fish. The turtle approached with great rapidity behind the darting fish until its victim was within reach of its snake-like neck; then

there was a lightning-like movement of the head, which shot out like a dart, and the trout was caught. *Amyda mutica* is much less vicious than is *Amyda spinifera,* but its disposition is by no means docile. If cornered, it snaps viciously at any offending object, the head shooting forward for all the world like that of a snake. It is this fact of relative tempers of the two species which has won for the milder *mutica* the local name of "queen" turtle, while its more voracious relative is known as the "king" turtle. The edges of the jaws are as keen as a knife, and the jaws themselves are powerful enough to inflict a painful injury.

As already mentioned, *A. mutica* is a river species. It is able to swim against a strong current, and that this is often and consistently done is indicated by the fact that, as Garman (1892) has pointed out, it is found abundantly below the various dams on the Illinois River, these dams impeding possible further progress upstream. If it habitually traveled down stream, it would be found abundantly above the dams, where in fact it is rare. Since the species is so very aquatic, the dams form efficient barriers to its progress.

Nesting Habits.—There is little information about the nesting habits of this turtle available, and the writer has only once, and then imperfectly, seen the nest digging, which is apparently very similar to that of *A. spinifera.* When leaving the water, the female is extremely cautious and very alert for possible danger. The head is held high and the vicinity is carefully inspected for possible dangers. The female does not go far from the water if suitable nesting grounds are available close by; most nests the writer has found have been within fifty feet of the water's edge. Open sand bars in the larger rivers, or the sandy shore of an island free of vegetation are most desired, but the turtles come to the mainland if no such isolated spot is available. The nest is usually dug in clear sand. I have on occasion dug up the eggs of this turtle in very loose sandy loam, but never in a tight-packing soil, through which the young could not escape. It is believed that the hole is dug with the hind feet, though I have never been able to get close enough to this species to be certain of the fact, the fore feet remaining in place during the operation. Oftentimes several holes were started, but for some reason best known to the digger, each proved unsatisfactory and was abandoned until just the right spot was located—sand neither too hard nor too soft, neither too wet nor too dry. After laying, the turtle fills in the hole and, with the hind feet, rakes sand over the eggs, so as to leave but little trace in the disturbed area. Then the female scurries for the water. In the vicinity of Meredosia, on the Illinois River, all indications point to early July as the nesting season, for after about July 10 no females were secured with eggs in the oviducts ready for deposit.

EGGS.—The eggs of *A. mutica* are round and white, and are smaller than those of *A. spinifera* which they so closely resemble. The normal number laid by a female is from 18 to 22; the largest number the writer has obtained from a single nest is 31, while Muller (1921) reports 33. The number of eggs laid is proportional to the size (age) of the female, the young individuals laying fewer eggs than the old ones. This accounts for clutches of 5 or 6 eggs as are occasionally found. The average size of 116 eggs measured by the writer is 22.6 mm, as compared with 28.3 mm for *spinifera.* Incubation lasts approximately 70 days and, as pointed out by Muller, varies with conditions of heat and moisture; excessive moisture kills the embryo, while excessive drought simply retards the development. Describing the embryo in the egg, Muller says: "The carapace is folded down around the young turtle, and the arms are extended in front of the head. The forepaws are thrust through the shell first in hatching, and this opening enlarged to allow egress for the rest of the body. Although the young have an egg tooth below the flexible proboscis, it does not seem to be used in escape from the egg, and is dropped a week after hatching. They always hatched during the night or early morning." On hatching the young turtle is almost perfectly circular, about 34.5 by 33 mm.

FOOD HABITS.—*Amyda mutica* is distinctly a carnivorous turtle, though vegetable matter does play a minor rôle in the diet. The food consists principally of crayfish, fish, frogs, tadpoles, the larger insect larvae and nymphs, and aquatic mollusks. The fish eaten are for the most part minnows, the large shiners *Notropis heterolepis heterolepis* and *N. whipplii spilopterus* frequently appearing in stomach examinations; other species of fish identified are: *Notropis hudsonius selene, Helioperca macrochira, Lepibema chrysops, Perca flavescens, Catostomus commersonii commersonii, Hepentelium nigricans.* The mollusks eaten are both gastropods and bivalves, the latter being thin-shelled species of small size, but there is seldom sufficient evidence of the shell left to afford identification. Over (1923) reports "young fowl" as an item of diet; Agassiz (1857) reports the larvae of neuropterous insects; Von Wied (1865) reports LeSueur's record of worms, snails, fruits, and even hard nuts; Hay (1892) reports this species as very fond of potato stems. It is only to a slight extent a scavenger.

ENEMIES.—Great numbers of the eggs of this turtle, as well as of *A. spinifera,* are dug out of their sand nests by skunks and raccoons, and the empty shells strewn around the ravaged nesting site bespeak a not inconsiderable havoc wrought by these nocturnal marauders. The adult turtle is so capable of caring for itself that it has but few enemies other than man himself. One might expect ectoparasites, such as leeches (*Placobdella parasitica*), would find the exposed soft parts of these soft-

shelled turtles an ideal feasting ground, but, since *A. mutica*, at least, shuns vegetation and quiet water where leeches are most abundant, it is but seldom attacked by these animals.

ECONOMIC IMPORTANCE.—Like *A. spinifera, mutica* is a most palatable turtle and is highly desired for table purposes. It is inferior to *spinifera* only because of its somewhat smaller size. Despite this fact, the soft-shelled turtles are seldom found in the markets of the larger cities. Clark and Southall (1920) report: "None was seen in the Washington market nor in Chicago, where it was reported that 'they could not be given away, much less sold.' And yet, where well known, the soft-shell is regarded as the most delicious of turtles. It is, indeed, a species of soft-shell turtle which is raised in Japan much as the diamond-back terrapin is beginning to be raised in this country."

Amyda spinifera (LeSueur)

(Spiny soft-shell; king turtle; leatherback; soft-shell)

Trionyx spiniferus LeSueur 1827
Trionyx ferox (part) LeConte 1830
Platypeltis spinifera Fitzinger 1835
Gymnopus spiniferus (part) Duméril & Bibron 1835
Trionyx ferox Dekay 1842
Tyrse argus Gray 1846
Trionyx argus Gray 1855
Aspidonectes spinifer Agassiz 1857
Gymnopus olivaceus Wied 1865
Callinia spinifera Gray 1869
Trionyx spinifer Boulenger 1889
Aspidonectes spiniferus Rhoades 1895
Amyda spinifer Hurter 1911

DESCRIPTION.—Seen from above, the carapace is broadly and bluntly ovate. It is covered with a soft, leathery skin, the horny scutes being entirely absent. The ossification of the carapace is incomplete, the ribs extending beyond the periphery of the costal plates; the marginal plates are entirely absent, permitting the edge of the carapace to droop over the limbs and head. The shell is greatly depressed, and nearly flat. There are no emarginations of any kind, the margin being entire. The dorsal surface of the carapace is often finely granular, like fine sandpaper, and there is a series of conical tubercles along the anterior margin. The plastron is likewise incompletely ossified, the elements being loosely associated and reduced in size. The plastron is anterior in position, its anterior margin being in a vertical line with that of the carapace, while the posterior limits are only about two-thirds the distance back when compared to the carapace. It is so placed as to afford complete protection to the withdrawn head, neck, and fore limbs, but none whatsoever to the hind limbs and tail, which are at all times fully exposed. The neck is extremely long and is capable of extension to nearly three-fourths the length of the carapace. The head is small and pointed, the skull depressed. The snout is prolonged forward into a soft, slender, tube-like proboscis with terminal nostrils. These nostrils are concentric, or reni-

form, and show a lateral ridge on each side of the nasal septum. The jaws are powerful and possess a sharp cutting edge, but are concealed laterally by fleshy lip-like flaps. The limbs are large and powerful, the feet large and fully webbed. Digits 5-5; claws 3-3, the three inner digits on each foot being supplied with well-developed claws, the remaining being without claws and concealed in the webbing. The tail is large and fleshy anterior to the anus, and much attenuated posterior to it; it projects beyond the edge of the carapace, with the anus close to the tip.

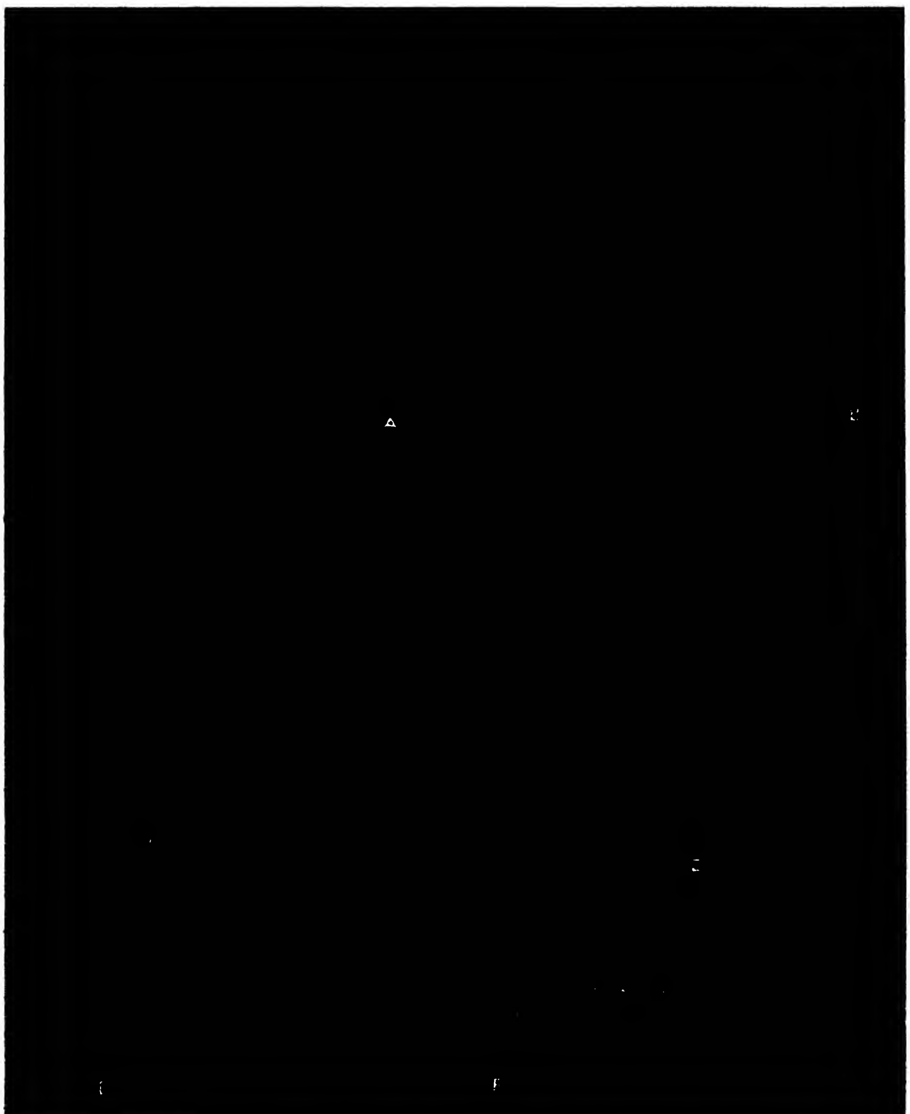


PLATE 25.—*Amyda spinifera: A,* Adult male, ventral view. *B,* Adult male, dorsal view. *C,* Lateral view. *D,* Young, dorsal view. *E,* A congenital deformity in a sexually mature female. *F,* Head study of an adult.

Coloration.—Carapace olive green or light brown, margined with yellow. This margin is widest along the posterior border, becoming narrower anteriorly. Between the yellow margin and the body of the carapace is an interrupted, wavy black line. The carapace is dotted with numerous dark brown spots, those nearest the margin being smallest and darkest. Toward the mid-dorsal line these spots become larger and each is surrounded with a black ring. The nature of these ocellated spots varies greatly with the age of the individual; they are regular and very conspicuous in the younger turtles, becoming irregular in outline, larger in size, and less bright in mature specimens, finally fading into irregular blotches, with little if any symmetry. The plastron and under surface of the carapace is immaculate, white, or ivory in color, and the plastral elements tend to show through as a purplish discoloration. The head and neck are olive. A pale yellow stripe edged with black extends along the neck, passing through the eye and on to the snout where, at the tip, it is joined by its fellow from the opposite side; a similar stripe extends backward from the angle of the jaw. The legs and feet are olive, mottled with black, the legs dorsally, the feet both above and below. The anterior

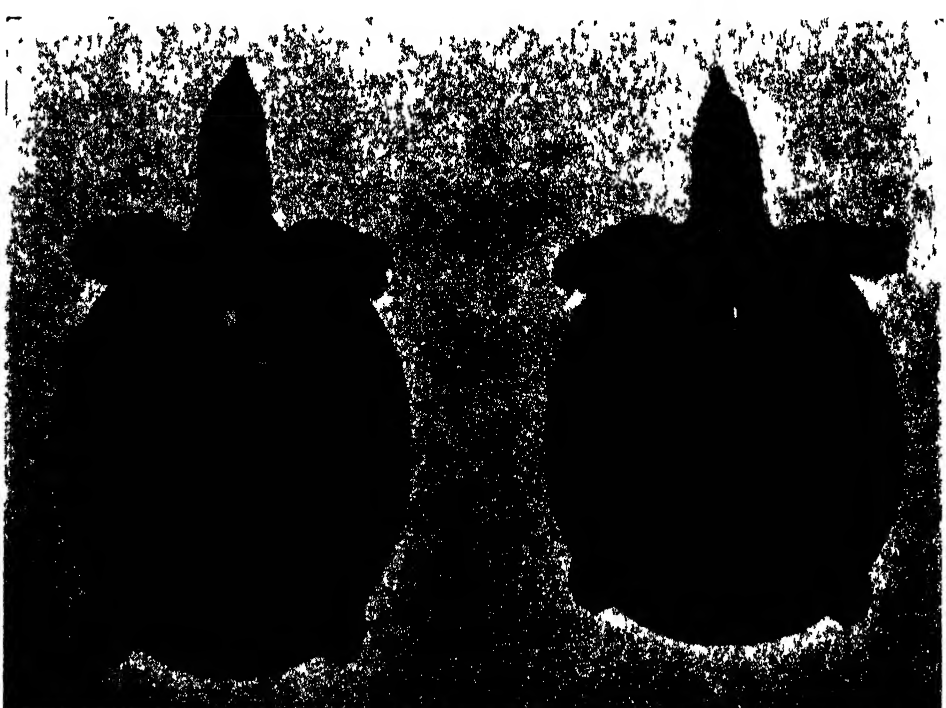


Plate 26.—*Amyda spinifera: (Left)*—An immature individual, six and a half inches long, which lacks the typical spotted markings, having instead lichen-like patches of dark pigment. *(Right)*—A typically marked immature individual of nearly the same size.

limbs bear a series of transverse scales dorsally; the posterior limbs bear a single transverse scale. The tail is olive, with a black-bordered yellow lateral stripe.

YOUNG.—The young resemble the adults in all essential details of form and coloration. In the young specimens the ocellate spots are bright, regular, and conspicuous, these dimming and becoming irregular in older individuals. The granular surface of the carapace is more pronounced in the younger specimens.

SEX DIFFERENTIATION.—The tail of the male is much longer than that of the female, and projects farther beyond the posterior edge of the carapace; it is also heavier and fleshier. The granular finish of the surface of the carapace is more pronounced in the female than in the male, and the tubercles on the shield are larger and more numerous on the female than on the male.

GEOGRAPHIC DISTRIBUTION.—"Mississippi River and tributaries, west to Colorado, north to Montana; St. Lawrence River and tributaries; east to Vermont, western New York and Pennsylvania" is the range as given by Stejneger and Barbour (1923). Babcock (1919) records the species for Vermont from Lake Champlain, the only New England record, and Surface (1908) records it from rivers in Pennsylvania. Morse (1904) says that it is found in every stream in Ohio, and Ruthven *et al* (1928) report it from the southern half of lower Michigan. Hay (1892) reports it as the commonest soft-shelled turtle in Indiana, occurring throughout the state; it is interesting to note that the type locality is New Harmony, on the Wabash River. Swinging southward we find Blanchard (1922) recording it from western Tennessee, where I have found it abundant in Reelfoot Lake; Haltom (1931) records it for Alabama. The writer has specimens from Louisiana, where Beyer (1900) reports it as abundant inland; apparently it does not occur in Florida. It is not recorded from Texas, where Strecker (1915) reports only *A. ferox* and *A. emoryi*. In western Oklahoma only *A. mutica* is reported by Ortenburger and Freeman (1930), and only *mutica* is recorded from Arkansas by Hurter and Strecker (1909). Hurter (1911) reports it from numerous rivers in Missouri, and Burt (1927) records that *spinifera* is more common in Kansas than is *mutica*. Ellis and Henderson (1913) record it as being common in Colorado, making no mention of *mutica*, yet Over (1923) reports only *mutica* from South Dakota. Blanchard (1922) reports *spinifera* from Iowa. Higley (1889) says it is found in southern and western Wisconsin, and Pope and Dickinson (1928) report it as "statewide" in Wisconsin; Cahn (1929) records it from southern Wisconsin. To the north Nash (1906) says that it is "distributed in all marshy waters of western Ontario, not common anywhere."

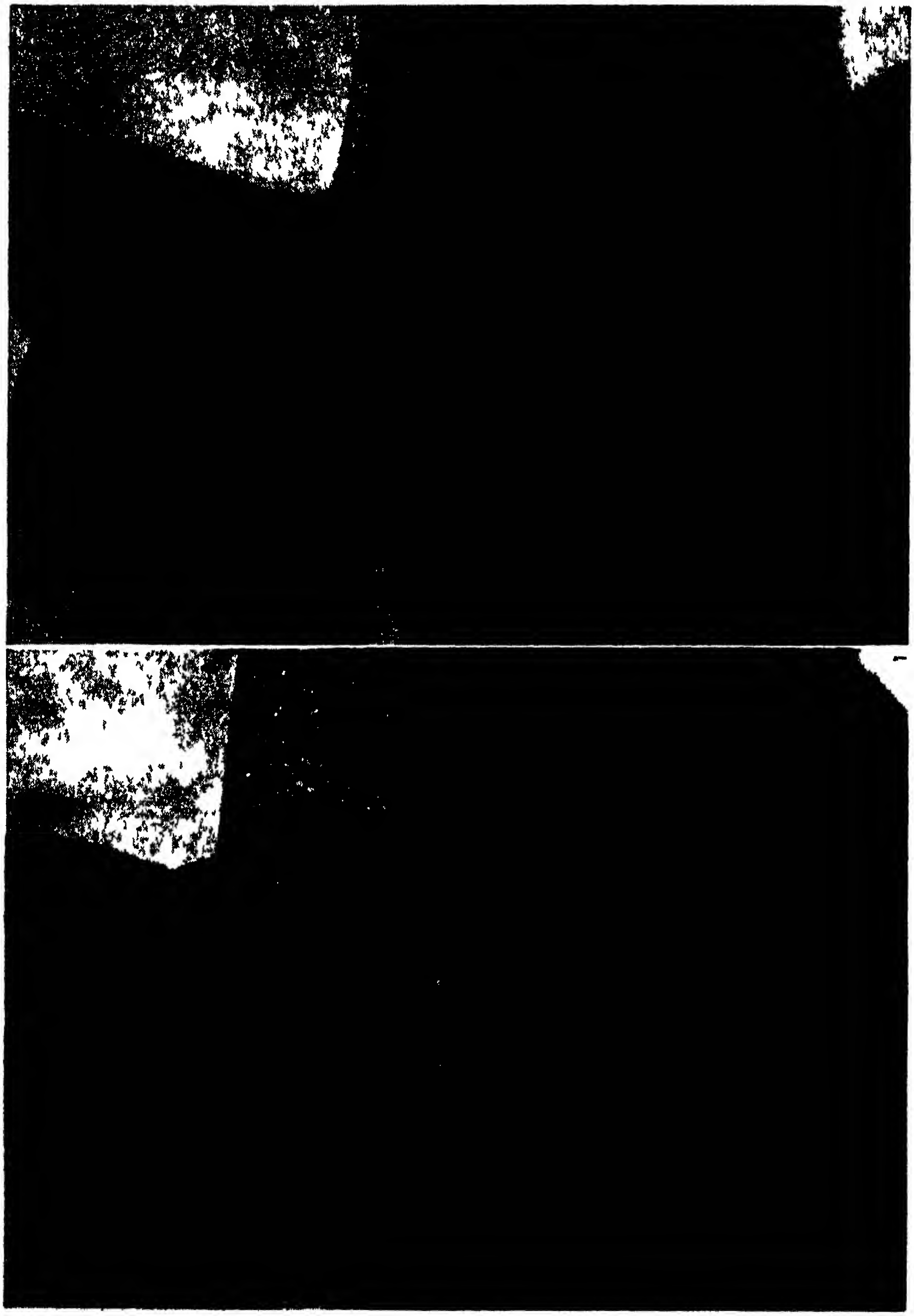
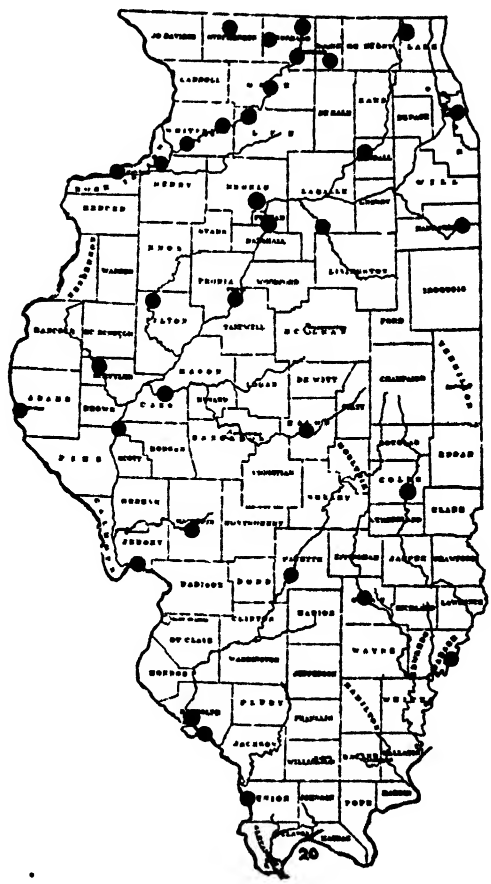


PLATE 27.—*Amyda spinifera: (Above)*—Study of the surface of the carapace to show the highly granular surface. *(Below)*—Study of the anterior margin of the carapace to show the terminal marginal row of tubercles characteristic of the species.

ILLINOIS RECORDS.—*Amyda spinifera* is distributed throughout the state of Illinois, and is an abundant species. Davis and Rice (1883) record it from Lake Michigan and as abundant in the rivers of the state. Garman (1888) reports it as abundant in the Quincy region, and in his state report (1892) gives records of it from Rock Creek in Plano County, Oregon, Quincy, Peoria, Bluff Lake in Union County, and Mt. Carmel. Hankinson (1917) found it in the Embarrass River at Charleston, and Weed (1923) reports it from Meredosia. The Field Museum has specimens from Momence, Jackson Park in Chicago, Havana, Meredosia, and Grafton. The writer has examined specimens from the following localities: Meredosia, Havana, Bureau, Chester, Peoria, Crooked Creek in Schuyler County, Rock Island, Barstow, Hillsdale, Sterling, Rockton, Freeport, Belvidere, Fox Lake, Decatur, Vandalia, Louisville, Chandlerville, Carlinville, Ellisville, the Kaskaskia River at Reilly Lake, and Streator.



MAP 20.—*Amyda spinifera.*

HABITAT.—The spiny soft-shelled turtle is preëminently a shallow-water species, inhabiting lakes, ponds, and rivers which have a soft sandy or muddy bottom, and avoiding those waters having much current or rock and gravel bottoms. It is less dependent upon aquatic vegetation than are other species of pond turtles, for it depends upon its ability to bury itself in the soft bottom when concealment is necessary rather than upon hiding among aquatic plants. Its swimming power enables it to cope with the current of even the largest rivers.

HABITS.—This turtle is exceedingly aquatic, spending by far the greater part of its life in the water and leaving this congenial environment only for some extraordinary reason and to lay its eggs. In the soft mud or sand at the bottom of a shallow lake or river this species buries itself with great rapidity by flipping the light silt over its back until it is

wholly concealed from view. Usually only the tip of the snout projects from the dirt covering. This burial usually takes place in water so shallow that the turtle can extend its long neck sufficiently to protrude its nostrils enough above the surface to breathe, all this without uncovering or disturbing its body. Thus it may lie concealed, at rest, for hours. The position of the body is always horizontal, and the covering is only a thin film of sediment. The ability of these turtles to remain for long periods—many hours—beneath the surface without reaching air has been demonstrated by Gage (1886), who showed a true aquatic form of respiration for both *spinifera* and *mutica*. He showed that there is a rhythmic movement of the hyoid apparatus at the rate of 16 movements per minute. By the raising and lowering of this structure the mouth and pharynx are filled with water and then emptied. The mucous membrane of the pharynx is highly vascular, the capillaries lying in filamentous villi-like processes, and these function as gills. Further, an analysis of the water in which the turtle was confined for hours without access to air showed that the oxygen supply was greatly depleted and that the water contained a large excess of carbonic acid.

Being thus so highly aquatic, it is not surprising to find this species a remarkably fine swimmer, capable of extremely rapid movement. In fact the entire creature is adapted to just this type of life, and to a higher degree than is found in any other fresh-water turtle. The excessively depressed body, the thin and flexible cutting edge of the carapace, the placing of the limbs in such a position that they propel the animal from a point beyond the hindrance of the carapace, the great webbing of the feet, all unite in making the soft-shells the fastest moving and most agile of our turtles. In swimming, the neck is extended forward in a straight line; the limbs strike out horizontally left and right, alternating in their action. So great is their speed that they are able to capture the fastest of our fishes. Whey they crawl leisurely on the bottom, we find the limbs are attached in such a position that only the inner two toes can touch the ground, and so buoyant are the turtles that they are incapable of rapid walking when submerged. On land their locomotion appears awkward, yet here they are capable of getting up surprising speed. When one is in full retreat you must "trot along right smart" if you would keep up with it or capture it.

When disturbed the turtle withdraws within its shell with remarkable completeness. Agassiz (1857) thus describes the performance:

The neck and head are withdrawn entirely within the shield, the skin rolling off from the greater part of the neck and allowing it to protrude naked among the viscera. The legs are withdrawn horizontally and the skin slips off so far that it does not surround them, except below the knees and elbows. When thus withdrawn, the humerus is carried round into or before the widespread scapular arch, the elbow being placed very near the head or neck; the fore leg and foot are

turned back upon the humerus, the flat surface of the foot being nearly horizontal, so that its outer edge rests against the femur, and the foot again turned somewhat forward, its flat surface being nearly horizontal.

The long, supple, snake-like neck is a great asset to the turtle in capturing its prey. So long is the neck that the creature can almost reach your fingers when you hold it by its tail. Yet one would never suspect its extensibility when the turtle is behaving quietly. Its disposition is pugnacious and irritable and it strikes forward or laterally with lightning speed and perfect accuracy. The jaws are powerful and the bite extremely painful, for the jaws very easily cut deep into the flesh.

Amyda spinifera goes into hibernation toward the end of October, burying itself to a depth of about two to four inches in the mud or sand at the bottom of the lake or river. The burial is accomplished by flicking at the sand with the feet and permitting it to settle over the carapace. It emerges again in May or, if the season is a warm one, toward the end of April. In the southern part of the state there is evidence pointing to the conclusion that the species does not go into complete hibernation, remaining sluggishly active all winter.

NESTING HABITS.—As the time for egg laying approaches, this turtle shows signs of forsaking its normal aquatic habits and may sometimes be seen basking in the sun close to the water's edge, completely out of water. At such times the turtles lie flat upon the plastron, with all four legs fully extended and the toes widely spread, completely relaxed. The hind feet rest upon the inner toe, the soles directed upward and inward. The least disturbance, however, is sufficient to send them plunging back into the water and they then show a marked timidity about returning to their sun bath.

When the female comes out to lay, so cautious and alert is she that it is almost impossible to observe her activities from a point sufficiently close to see what is actually going on. This difficulty Mr. Combs overcame by sitting up in a tree for hours at a time, observing the turtles through powerful binoculars. The nesting performance is as follows: A female about twelve inches long left the water at 11:15 on the morning of July 11, 1931. She progressed only about four feet from the water when she turned and went back into the river, entering, however, only the shallows. A few minutes later she repeated the performance and returned again to the water. A third time she came out some five feet up stream, at a point where the willow brush was less dense and the sand more abundant. She held her neck erect and very stiff, and advanced with extreme caution. After traveling 18 feet from the water, a distance which it required about 15 minutes to cover, she came to rest and remained entirely motionless, neck fully extended, for two minutes. Then, very deliberately, she planted her fore feet firmly in the sand, and began

scratching slowly with her hind feet. From the time she planted her front feet until the eggs were laid and the nest covered, she never moved the fore feet from this spot. In digging the hole she made two or three slow, heavy scratches with one hind foot; this was followed by a sudden, violent kick which sent the dirt flying four or five feet behind her. Scratching then began with the opposite foot in exactly the same manner. Thus for 16 minutes she dug, alternating in the use of her hind feet, every third or fourth stroke shooting out the loose dirt which the preceding scratchings had loosened, building up a pile of dirt immediately behind her. During all the digging she held her head high, carefully watching.

As soon as the digging ceased, she drew in her neck and remained very quiet for 8 minutes, during which time the subsequent examination of the nest showed she laid 12 eggs. Then, her front feet still in their original position, she began filling in the nest. This she accomplished by extending her hind feet backward and raking into the hole the loose sand her excavating had piled up. With the front feet acting as a fixed pivot, she rotated her body and hind legs through an arc of about 90°, dragging in all the loose sand within reach. As soon as this was completed to her satisfaction, she wheeled quickly about and without a glance behind her at the nest which she never saw, hurried back into the water.

Then the nest was examined. It was found to consist of a hole descending at an angle of about 60°, the opening at the surface lying under what was approximately the middle of the plastron while the animal was digging. Thus the eggs when laid were deposited upon an inclined plane down which, being spherical, they rolled. It could not be determined from the point of observation whether or not the hind legs were used in lowering the eggs into the hole. A second interesting fact was that the sand which surrounded the eggs was very much wetter than the surrounding material. From this the obvious conclusion must be drawn that the female, as she packed in the sand around the eggs while filling up the hole, wetted it down, undoubtedly with water stored in the cloacal region. The utilization of water in this manner has been observed in the case of other turtles. The sand at the surface was so neatly packed down that the nest site was almost invisible.

As we have mentioned, the eggs are spherical, and each is covered with a thick, strong, and rather brittle calcareous shell which is less flexible than the shell of many other turtle eggs. In this respect the eggs of the family Trionychidae, Chelydridae, and Kinosternidae differ from those of all the rest of our inland turtles, though the last-named group does not lay spherical eggs. Beneath this shell lies a very tough membrane. The shell is pearl white in color, quite smooth and unglazed. Agassiz (1857) reports the number of eggs laid as "from twelve to

twenty or more," while Surface (1908) and others report the number as "about 60." I doubt if any *A. spinifera* lays this number of eggs in a season, and assume that the authorities for these high numbers include in the count all of the larger eggs found in the ovaries as well as the shell-covered eggs about to be laid which are in the horns of the uterus, the counts having been made from dissected females rather than from dug-out nests. This is obviously unfair, for the larger embryonic eggs are retained *in situ* for laying the following spring. My experience shows that the number of eggs laid by females in Illinois is as follows: 9, 12, 13, 15, 17, 19, 19, 21, 22, 22, 23, 25, with the average of this series as 18. The eggs are large, measuring 28.3 mm as the average for 217 eggs, with the largest measuring 29.3 mm. An examination of the ovaries inclines me to the belief that this species must attain a carapace length of about 24 cm before the females become sexually mature.

There are no data available as to the exact duration of incubation and no doubt this period, whatever it may be, is varied considerably both ways from a mean by climatic and soil conditions: by the type of soil in its relation to heat and moisture retention, by temperature and by rainfall which cools off the soil and hence may slow up the rate of development. Most of the Illinois turtles of this species lay in June or early July: earlier in the southern part of the state, later in the northern portion, and young-of-the-year are taken in late August and September. Further, there is no information at hand or available dealing with the rate of growth after hatching. The only material of this nature to which we can refer is offered by Mitsukuri (1905) for *Amyda japonica* (*sinensis* ?), a closely allied species, as follows:

Age	*Length in cm*	*Width in cm*	*Weight in gms*
Just hatched	2.7	2.5	...
First year	4.5	4.2	23
Second year	10.5	8.8	169
Third year	12.2	10.5	300
Fourth year	16.0	13.5	563
Fifth year	17.5	15.1	750

Food Habits.—*Amyda spinifera* is conspicuously carnivorous in its diet. The commonest items of food found in stomach examinations are: crayfish (*Cambarus* spp.), minnows, fry of larger fish, frogs, tadpoles, earthworms, insects (often beetles), and mollusca (*Piscidium, Planorbus, Vivipara,* etc.), in the order named. Sometimes aquatic vegetation is found, but this is not common. Among the fish that have been identifiable I note: *Notropis heterodon, N. heterolepis heterolepis, N. hudsonius selene, Catostomus commersonii commersonii, Allotis humilis, Helioperca macrochira, Semotilus atromaculatus atromaculatus, Abramis crysoleucas,*

Umbra limi, and *Aplites salmoides*. In Wisconsin I found the remains of brook trout (*Salvelinus fontinalis fontinalis*) six inches long in the stomach of a 13-inch turtle, attesting the speed and agility of the species in capturing its food. It is also a scavenger, picking up a lot of débris from the shallow water.

Economic Importance.—According to Clark and Southall (1920) this turtle seldom finds its way into the large market centers of the city and certainly it is far more seldom seen there than the snapper. This is due no doubt to at least two important factors. First and foremost is the fact that the river fishermen who capture these turtles recognize their delicious table qualities, and they are disposed of at the local markets near the point of capture without the necessity of shipment to distant markets. In the second place they are far more delicate than the hardier snapper and consequently they do not stand shipment as well. Be that as it may, the spiny soft-shell is a delightful table delicacy, the very nature of its food supply insuring its meat of a palatable flavor. Along the Illinois, Rock, and Mississippi rivers particularly, thousands of pounds of these turtles are captured annually and bring a good price on the local markets. Hence the species must be regarded as of considerable economic importance. This fact the state recognizes and has placed a minimum size limit of 7 inches on all of the species of soft-shelled turtles.

Table 20.—Measurements of Illinois Specimens of *Amyda spinifera*
(Measurements in millimeters)

Specimen No.	Carapace		Plastron			Tail	
	Length	Width	Length	Width	Depth	Total	A-T
1.........	168	142	110	55	35	76	8
2.........	159	132	119	59	36	75	8
3.........	172	149	126	57	34	86	9
4.........	176	153	130	61	37	86	10
5.........	141	119	100	61	29	63	5
6.........	124	104	88	39	22	43	5

HYPOTHETICAL LIST

After a careful study of the turtles now found within the state of Illinois, and a careful review of the literature bearing on all of these forms, it has become necessary to designate certain species as hypothetical within the state. By this term is meant (1) that the form is no longer to be found within the state, if it ever actually did occur there; (2) that it is no longer a valid species; or (3) though not taken in the state, its occurrence there is possible. The task of evaluating early records when the

original material is no longer available is very difficult at all times; it is made more difficult still by the fact that the early investigators did not distinguish between subspecies and they did not clearly see the relations between closely allied forms in the light in which we do now. There are some species reported from Illinois which the writer cannot verify. In view of this fact it has been considered advisable to segregate them out of the main body of the paper, yet, since they appear in the literature, the student is entitled to know what has become of them, and why. In this list, then, we attempt to explain why certain forms have been deleted from the state list, and to point out certain other species which, for one reason or another, may possibly be found within the state by future investigators.

Of the six species placed in this list, three are apparently errors in previous identifications: *Sternotherus carinatus, Chrysemys picta,* and *Amyda ferox;* one is considered as being no longer valid: *Chrysemys treleasei;* one is believed to be of exceedingly doubtful occurrence: *Pseudemys hieroglyphica;* and the remaining species, *Clemmys insculpta,* while never taken in Illinois, has been captured within eleven miles of the boundary of the state and hence may be taken in the state at some future time.

Sternotherus carinatus (Gray)

Aromachelys carinata Gray 1855
Goniochelys triquetra Agassiz 1857
Cinosternum carinatum Boulenger 1889
Sternotherus carinatus Stejneger 1923
Kinosternon carinatum Stejneger & Barbour 1917

DESCRIPTION.—Carapace elongatedly oval, rather narrower at the posterior end than at the anterior; very high and massively domed; in profile steeper behind than in front. A prominent, sharp keel becomes particularly evident on the second vertebral scute, and increasingly prominent from here backward, the nearly flat sides forming a straight slope from keel to marginals. The scales are all highly imbricated; the posterior margin of each scute overlaps the anterior margin of the succeeding scute as do shingles. The vertebral scutes are all very nearly the same in length. The first vertebral is triangular, the apex directed posteriorly, and much longer than its anterior width. The second and third vertebrals are rhomboidal, their length closely approximating their width. Fourth vertebral usually longer than wide; the fifth vertebral is the smallest of the series. The median keel arises gradually from the vertebrals and appears as a continuous sharp median ridge. The costal scutes are all very large, the first being by far the largest of the series. Second and third costals highly rectangular; fourth costal irregular in shape. The posterior three costals are pentagonal; the anterior roughly rhomboidal. Nuchal very small and insignificant. Lateral marginals rectangular; the tenth and eleventh (the latter the supracaudalia) are much higher than

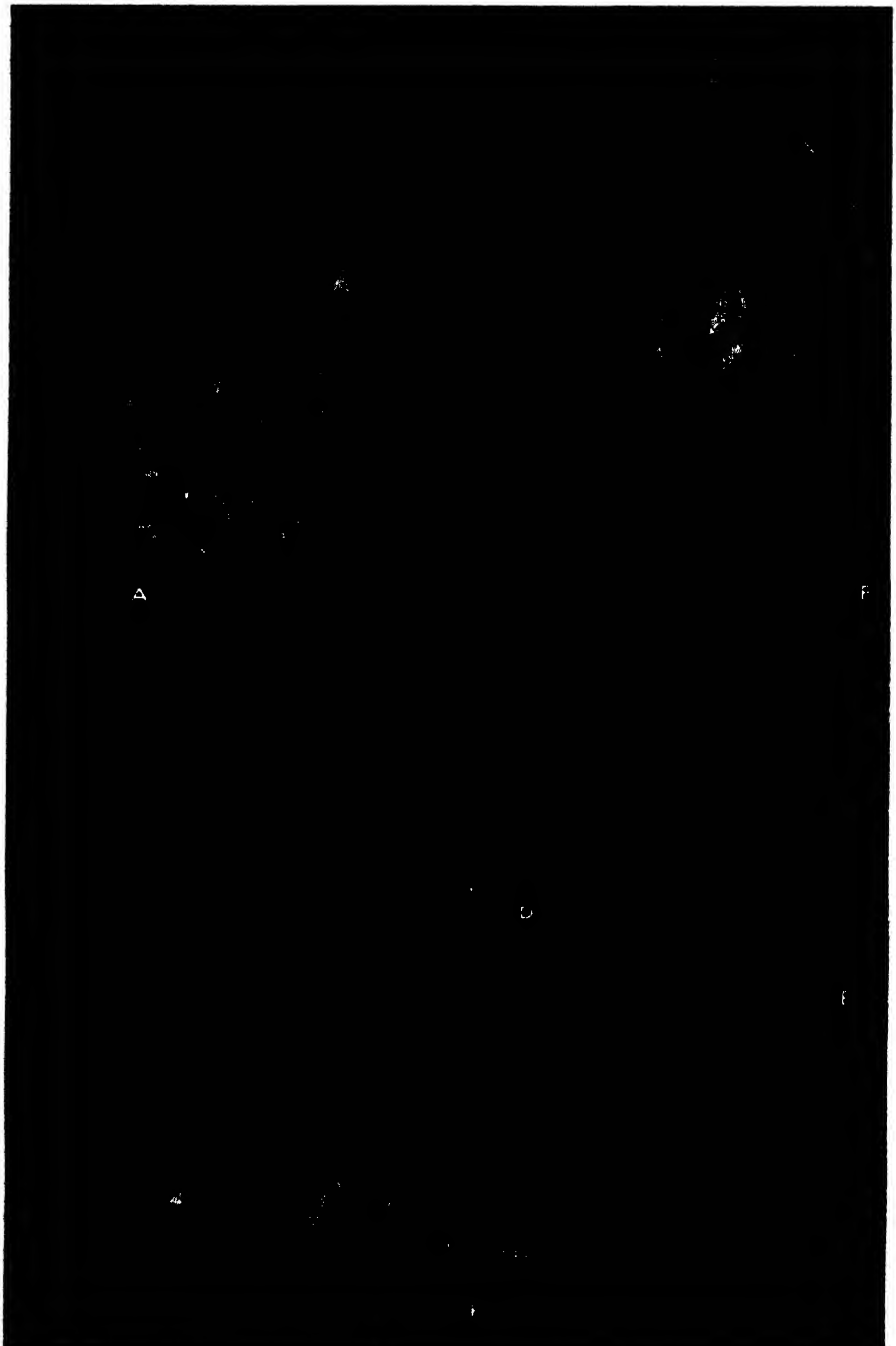


PLATE 28.—*Sternotherus carinatus: A,* Adult, ventral view. *B,* Adult, dorsal view. *C,* Newly hatched young, ventral view. *D,* Posterior view of the carapace to show the arrangement, relative size and shape of the posterior marginal scutes. *E,* Newly hatched young, dorsal view. *F,* Adult, lateral view.

the rest of the series, the eleventh being higher than the tenth. The highest point of the eleventh marginal is toward the anterior margin. The plastron is small, tending toward cruciform, and does not nearly close the aperture of the shell. The anterior lobe is truncate along its forward border, and is wider than long. The posterior lobe is longer than wide, is approximately one-half as wide as the aperture in that region, and has a wide, shallow posterior emargination. The front lobe is about two-thirds the length of the hind lobe, but longer than the intermediate portion. The gular is absent in most specimens, so that the humerals form the anterior termination of the plastron. The humerals are roughly triangular, the interhumeral suture being shorter than the humeral-pectoral suture. Pectorals larger than the humerals, rhomboidal. Abdominals the largest of the plastral elements. The femorals are much longer than wide and tend toward the triangular in general form. The anal scutes are rhomboidal, terminating posteriorly in a sharp projecting angle, the lateral tip of the posterior emargination. The inguinal and axillary elements touch at their proximal ends and form the major part of the bridge, completely separating the short wings of the abdominal from the marginals. The axillary is triangular and is smaller than the rhomboidal inguinal. Head large, massive; snout rather short but pointed. The nasal plate is strongly forked. Jaws strong, with sharp cutting edges. Gular barbels two; well developed. Legs and feet strong; toes webbed. Digits of fore limb all with small claws; fifth digit of the hind foot without a claw, and the anterior (first) digit with only a tiny one. Fleshy parts posterior to the hind legs covered with small fleshy tubercles tending to arrange themselves in lines along the tail. No terminal claw or nail present on the tail.

Coloration.—Carapace varies in color around olive green. Each scute is mottled with chocolate brown spots and dashes which sometimes tend to extend into radiating lines, the number, conspicuousness, and extent of these varying enormously but usually plainly in evidence. The posterior margin of each scute, where it overlies the succeeding posterior scute, is bordered by a conspicuous but narrow black line. Dorsally the marginals bear the same black border along each overlapping suture. Plastron is horn color to yellowish, unmarked in most specimens, but occasionally exhibiting a very few short brown dashes. There is a large amount of cartilaginous material along the interabdominal, pectoral-abdominal, and interfemoral sutures, the amount varying with the sex of the animal. This material is usually pinkish in color. Head olive, covered with numerous small, dark brown flecks and spots both dorsally and laterally; there is no stripe back of the eye. Neck and chin pinkish gray, also spotted, the spots lacking ventrally. Jaws horn color, with

transverse brown stripes, which are sometimes very faint. The rest of the soft parts are grayish in tone and without markings.

YOUNG.—The young resemble very closely indeed the young of equal size of *Sternotherus odoratus*, and might well be very confusing. In the young specimens there is usually a keel in evidence on both series of costal scutes, this keel becoming more and more obscure with age. The young *S. carinatus* lack the light stripes so conspicuous below and behind the eye in young and adult *S. odoratus*.

SEX DIFFERENTIATION.—In the male the "stridulating organs" are well developed on the hind legs as a series of scale-like roughenings. Usually the transverse brown stripes on the jaws are much more intense in the males than in the females. The amount of cartilage between the plastral elements is much greater in the males than in the females.

GEOGRAPHICAL DISTRIBUTION.—*Sternotherus carinatus* is distinctly a southern species. It inhabits the lower part of the Mississippi River Valley, the range covering Georgia, Mississippi, Florida, Louisiana, and westward to about the eastern third of Texas.

ILLINOIS RECORDS.—The only record of this species for Illinois is to be found in the list of Davis and Rice (1883) who state simply: "Has been taken as far north as Lake County." This Illinois record is taken seriously by Hay (1892) who quotes it in view of the possibility of finding the species in Indiana. Again, Garman (1896) quotes the same record and includes the species in his herpetological report of Illinois, mentioning, however, that he has not taken it in the state, and putting the responsibility for the record upon Davis and Rice. In view of the fact that a careful combing of the state during the last three years has brought to light not the slightest trace of the species, and because of the great distance which Lake County, Illinois, lies north of its known range, the present writer rejects it from the Illinois fauna. Yet, in view of the case of *Kinosternon flavescens,* he does so gently but firmly, and places it in the hypothetical list until positive evidence in the form of a specimen taken in the state comes to hand. The Davis and Rice material is not available for study. The writer is inclined to follow Siebenrock (1907, p. 552), who believes that Davis and Rice (he quotes, however, only the Garman citation) had *Sternotherus odoratus* and not *S. carinatus*. In view of the tendency of *S. odoratus* toward keels in the immature stages, this seems altogether likely.

Since the present writer is quite confident that *Sternotherus carinatus* does not occur in Illinois, and that the only published record for it within the state is in error, a further discussion of the species will be omitted. To those who are interested in the taxonomy of this species and of *Sternotherus minor* with which it has been badly confused, reference is made here to a paper by Stejneger (1906).

Chrysemys picta Schneider

Testudo picta Schneider 1783
Testudo cinerea Schneider 1792
Emys picta Schweigger 1814
Terrapene picta Bonaparte 1830
Chrysemys picta Gray 1856
Clemmys picta Strauch 1862
Chrysemys picta picta Bishop and Schmidt 1931

The last authority, in point of time, to include this eastern species in a list of the turtles of the state is Garman (1892), who says as follows: "Under the name of *C. picta,* this and the closely allied *C. marginata* are included by good authorities as varieties of one species, and as the former name has the right of priority, it has come to be commonly applied by students to the individuals of the genus taken in Illinois. It is probable, however, that *C. picta* will be found to be very rare in this State, if it occurs at all." He gives one locality record. Previous to the Garman list, it had been included in the Cook County, Illinois, list by Kennicott (1855), in which list the author says that it is "very abundant; exists throughout the state." However, previous to this time the validity of these two species *(picta* and *marginata)* was not understood, as Garman indicates, and when Kennicott reports *picta* as an abundant species there can be little doubt but that he referred to what we now understand as *marginata,* believing that *picta* and *marginata* were one and the same species. Garman refers to a specimen taken at Mt. Carmel, Illinois, probably using as his data the published record of this specimen in the Yarrow (1882) list. This record shows U. S. National Museum specimen #9559 to be *Chrysemys picta,* taken in 1878 by Shenck. The writer wrote to Dr. Stejneger in regard to this record, and through his kindness has learned that the specimen referred to under this number by Yarrow is in reality *Chrysemys marginata.* Hence the Yarrow record is eliminated, as is also the Garman record. The distribution of *Chrysemys picta* is given by Stejneger and Barbour (1933) as follows: "Eastern North America from New Brunswick to Florida."

Amyda ferox (Schneider)

Testudo ferox Schneider 1783
Testudo verrucosa Schoepff 1792
Testudo bartrami Daudin 1802
Trionyx carinatus Geoffroy 1809
Trionyx georgicus Geoffroy 1809
Trionyx brongnartii Schweigger 1814
Amyda ferox Oken 1816
Gymnopus spiniferus (part) Duméril & Bibron 1835
Platypeltis ferox Agassiz 1857
Gymnopus spiniferus Wied 1865
Platypeltis agassiz Baur 1888
Trionyx ferox Boulenger 1889
Trionyx agassiz Baur 1893
Aspidonectes agassiz Baur 1893
Pelodiscus agassiz Baur 1893
Trionyx agassizii Hay 1892

This southern soft-shelled turtle has been recorded but once for Illinois, and it is extremely doubtful whether it occurs within the state. This Illinois record is that of Kennicott (1855), who records this species as

"common in Lake Michigan and throughout the State." There can be little doubt but that Kennicott is in error here, for he makes no mention in his list of the turtles of Cook County of either *spinifera* or *mutica;* hence we must assume that he did not distinguish between the various species of the soft-shelled turtle. And if this is the case, we cannot possibly accept his identification of *ferox* as *the* common species of Illinois. Again, Yarrow (1882) records a specimen (#8359) in the National Museum, from Madison, Indiana, and this record constitutes the sole basis for the inclusion of this species in the list of turtles of Indiana as published by Hay (1892) under the name *Trionyx agassizii.* As to including it in the hypothetical list of Illinois: outside of the Kennicott record the only justification is to be found in the fact that Madison, Indiana, is on the Ohio River. Since *Amyda ferox* is, like the other species of the genus a highly aquatic species, and since it is a southern turtle, the most plausible route this specimen could have taken would be up the Mississippi to the mouth of the Ohio, and up the Ohio to Madison, Indiana. Hence, if the Indiana record is correct, it is just possible that sometime a stray specimen may again attempt a similar journey and be taken *en route* in southern or southeastern Illinois.

Chrysemys treleasei Hurter

Chrysemys treleasei Hurter 1911
Chrysemys marginata treleasei Stejneger & Barbour 1917

This species was described by Hurter in 1911 from specimens taken by him in Madison, St. Clair, and Monroe counties along the Mississippi River in Illinois. The description of the form is similar to that of the other species of the genus *(marginata, bellii),* and the basis for the founding of a new species lies in the coloration of the plastron. "The plastron is uniformly blood red in the adults, which color partly fades away in alcoholic specimens. When the red has faded the plastron sometimes shows a faint long and wide blackish mark. In the young of the first year the red plastron is divided into squarish fields by the proportionately wide yellow sutures." Bishop and Schmidt (1931), in reviewing the status of *treleasei,* give as their opinion that the red color of the plastron is due to a superficial deposit of inorganic red pigment (an oxide of iron), and point out that this is true of specimens in the Field Museum from the same locality which likewise show the red plastron. They further point out that the yellow sutures of the young individuals represent new growth of the horny shields, on which the superficial red deposit has as yet had insufficient time to become deposited. The writer has examined two specimens from Monroe county which were typical of Hurter's description of *treleasei,* and in both cases scraping with a knife revealed the red color of the plastron to be merely a superficial

deposit, with the normal yellow color underlying it. Hurter's statement that, on fading, the plastron sometimes "shows a faint long *and wide* blackish mark" indicates the true *bellii* affinities of the specimens he describes as *treleasei*. Those specimens examined by the writer were typical *bellii* when the red deposit had been removed. Bishop and Schmidt accordingly place *Chrysemys treleasei* Hurter as a synonym of *Chrysemys picta bellii*. With this view the present writer is quite in accord. Stejneger and Barbour (1933) have likewise placed *treleasei* in synonymy with *bellii*. Hence *Chrysemys treleasei* is deleted from the list of species found in Illinois on the ground of being an invalid species.

Pseudemys hieroglyphica (Holbrook)

Emys hieroglyphica Holbrook 1836
Ptychemys hieroglyphica Agassiz 1857
Clemmys hieroglyphica Strauch 1865
Chrysemys hieroglyphica Boulenger 1889
Pseudemys hieroglyphica Garman 1892
Pseudemys elonae Brimley 1928 (?)

The following description is taken from Hay (1892): "Head unusually small; snout somewhat projecting; upper jaw slightly notched in front; both upper and lower jaws smooth or slightly denticulated. Shell greatly depressed, and in large specimens without trace of keel. In specimens five inches long there is a slight keel. Shell sometimes smooth, occasionally longitudinally wrinkled. At its border, especially behind the thighs, the shell flares outward excessively, in some cases producing an actual concavity in the shell above. Hinder margin deeply serrated. The bridge is narrow from front to back, the width being contained in the length of the plastron about three times or more. It rises little toward the carapace, and this contributes to the apparent flatness of the shell. Hinder border of the plastron with a deep notch. Longest suture that between the abdominals; the shortest, that between the humerals. Digits all strongly webbed. Hind feet very large and flat.

"The ground color of the carapace varies from olive to dark brown. This is variegated with numerous lines and stripes of yellow. On the vertebrals the lines tend to run longitudinally. On the costals broad yellow bands divide each scute into three or four areas, inside of each of which are narrow concentric lines of the same color. The marginals are marked with yellow and brown. The plastron is yellow, with some splotches of brown on the bridge. The head, neck, feet, and tail are all dark green, with numerous longitudinal bands of yellow. The length of the shell of large specimens is 12 inches." Baur (1893) characterizes *hieroglyphica* by its elongated, narrow shell and its very small head; by the presence of yellow stripes and dots on the head which are much more distinct than in *P. concinna,* which it most nearly resembles.

The only records, apparently, for the occurrence of this species in Illinois are those of Garman (1892) and Hay (1892). Garman gives no locality records of any kind, and no mention is made of a single speci-

men having been taken or examined by him in Illinois. He merely says: "The species has been observed only in the Wabash River." For a turtle so nearly resembling another species *(P. concinna)*, this can hardly be accepted as a record or as a proof of its occurrence in the state. Turning to Hay, we find little satisfactory information. He says: "Two shells of this species are in the State collection, which were sent in from Mt. Carmel, Illinois, on the Wabash River. No doubt it will be found along the whole lower course of the Wabash." The writer has been unable to locate these two "shells"; correspondence with Mr. Verne Patty, the curator of this museum, indicates that *if* the turtles are still in this museum they are packed up and hence not available for study. So we must simply take Hay's statement and weigh it. In the first place, one would like to know what is meant by "shells." Presumably carapace and plastron. If so, one would like to know whether the coloration and scutellation was sufficiently distinct to distinguish it from the very closely similar *P. concinna.* Is one to assume that by referring to "shells" Dr. Hay wished to designate that no skull was present? Yet the best diagnostic feature to distinguish *hieroglyphica* from *concinna* is the smooth cutting edge of *both* jaws in *hieroglyphica* and the *serrate* edge of the *lower* jaw of *concinna.* Finally, Dr. Hay's prediction that the species would "no doubt" be found along the "whole lower course of the Wabash" has not been verified during the last forty-one years, for no further specimens have come to light. The writer has taken *P. concinna* from this Mt. Carmel region, but an especially vigorous search for *P. hieroglyphica* in that locality has yielded nothing. Stejneger and Barbour (1933) give the range of *hieroglyphica* as "the rivers of the southern Appalachians." Hence it would appear that Illinois is very far from the normal range of the species. There is in the Field Museum a specimen of this species (#6300), bearing the data: "Kankakee river at Kankakee." Correspondence from Dr. Karl P. Schmidt, of the Field Museum, states in regard to this specimen: "The *Pseudemys hieroglyphica* appears to be correctly identified, but the locality is quite untrustworthy as it is an aquarium specimen received from F. S. Young, but not collected by him. Any statement of this record should carry this notation. The occurrence of this turtle in the Kankakee requires confirmation." The only other nearby record is that of Levette (1876), who reports it, strangely enough, from the Kankakee River in northern Indiana! Therefore, since the writer has been unable to verify these old records, and since he has been unable to obtain a single specimen from the state, he feels that the species should be placed in the hypothetical list. If these old records are ever verified, and if in the meantime no new specimens are obtained, we may then assume that *Pseudemys hieroglyphica* has been exterminated within the state.

Clemmys insculpta (LeConte)
(Wood turtle)

Testudo insculpta LeConte 1830	*Geoclemmys pulchella* Gray 1865
Emys speciosa Gray 1831	*Glyptemys insculpta* Agassiz 1857
Emys insculpta Harlan 1835	*Glyptemys pulchella* Gray 1870
Clemmys insculpta Fitzinger 1835	*Chelopus insculptus* Cope 1875

Description.—Carapace ovate, approaching retangular, widest posteriorly across the eighth marginal scutes; depressed; flattened dorsally; serrate posteriorly. Scutes of the carapace very rough, sculptured. First and fifth vertebral with length and width about equal; remaining vertebrals wider than long and of almost identical size and proportions. First and second costals the largest of the series but only slightly larger than the third; fourth costal the smallest of the scutes of the carapace. Marginals vary in number, but usually show 24 plus the nuchal. (For a study of this variation, see Parker 1901). Nuchal elongate, narrow, deeply notched posteriorly where the anterior margin of the first vertebral projects sharply into it. Marginals all flaring, lying almost horizontal in position. Each scute of the carapace bears toward its posterior margin a "focal point," from which a few weak ridges radiate. From each focal point a series of fine, raised, concentric ridges radiate toward the margin of the scute, giving the shell a highly sculptured surface. The focal points on the vertebral and costal scutes are raised and form the apex of a flattened pyramid. A weak longitudinal keel is present on the vertebrals, most developed posteriorly. Plastron ovate, flat. Gulars triangular, their anterior lateral margins projecting into a blunt, rounded knob, their anterior margins rounded and emarginate. Anals trapezial, with a deep notch between them, the posterior angles rounded. Anterior margin of the anals less than the posterior margin of the femorals; hence the posterior lateral angle of the femorals forms a rounded protruding angle; posterior margin of the femorals deeply concave. Anterior lateral angle of the femorals extends into the posterior lateral margin of the abdominals, which "flows" around it to form the base of the bridge. Each scute of the plastron with a posterior lateral focal point which is, however, not raised, and with a series of concentric angular rugae extending from it. Axillary and inguinal elements small, the axillary triangular. Head flat or slightly dished dorsally, compressed, wider above than below; upper jaw projecting downward like a bill and notched at the tip. Edge of lower jaw straight except at the tip, which is highly arched upward. Alveolar surface of both jaws narrow. Soft parts (except head) covered with rough scales or blunt, wart-like protuberances.

Coloration.—Carapace a dull brown, with very faint yellow and black radiating and concentric lines which become very obscure in adult individuals. Plastron yellow, with a squarish black blot on the posterior

lateral margin of each scute except the gulars, on which the spot is anterior lateral. Dorsal surface of the gulars yellow, with black anterior area. Ventral marginals yellow, with a black posterior lateral blotch.

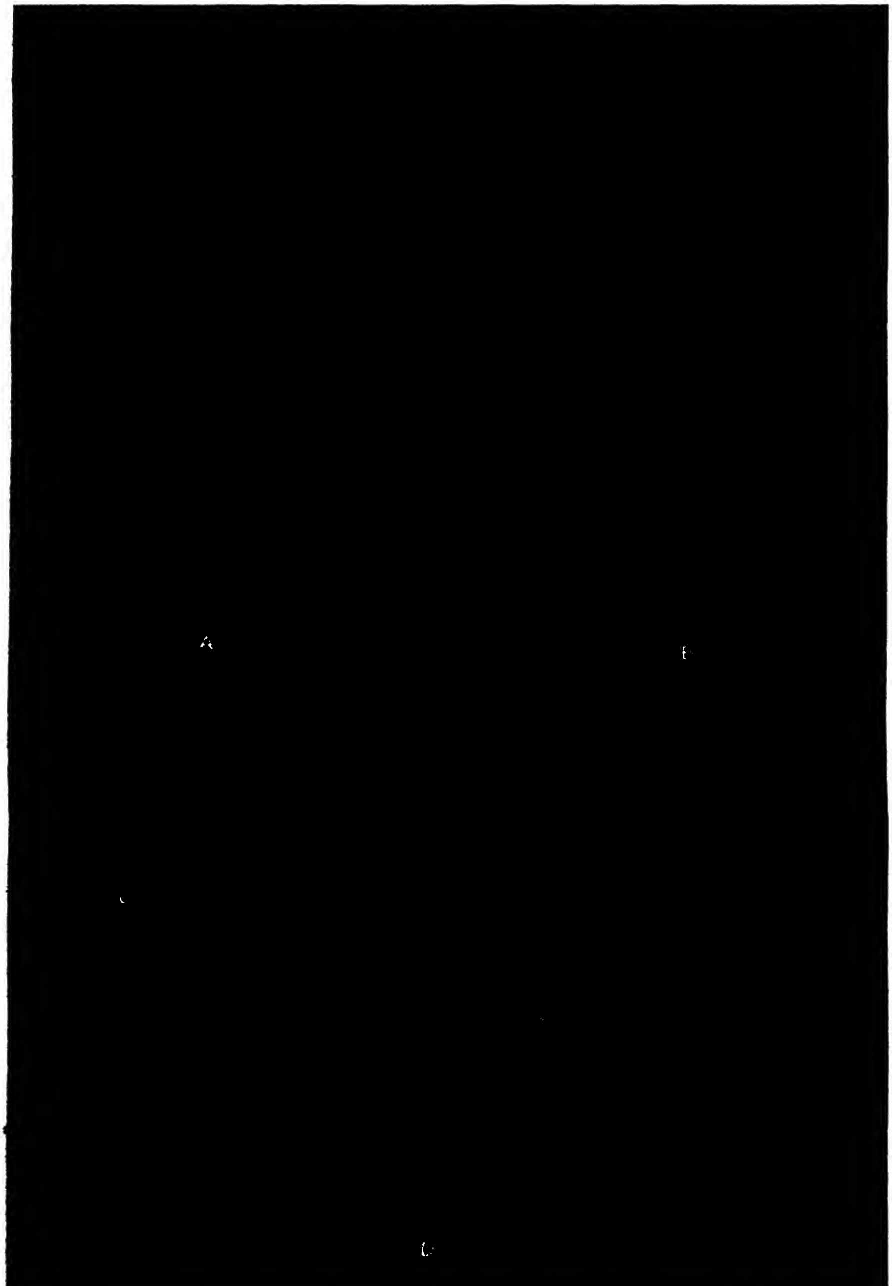


PLATE 29.—*Clemmys insculpta: A,* Adult, ventral view. *B,* Adult, dorsal view. *C,* Adult, lateral view. *D,* Head study of an adult. This specimen is from Wisconsin, close to the Illinois state line.

Soft parts yellow, orange, or red, with the dorsal surfaces dark olive green. Top of head and neck dark olive, blending into yellow on the sides of the neck.

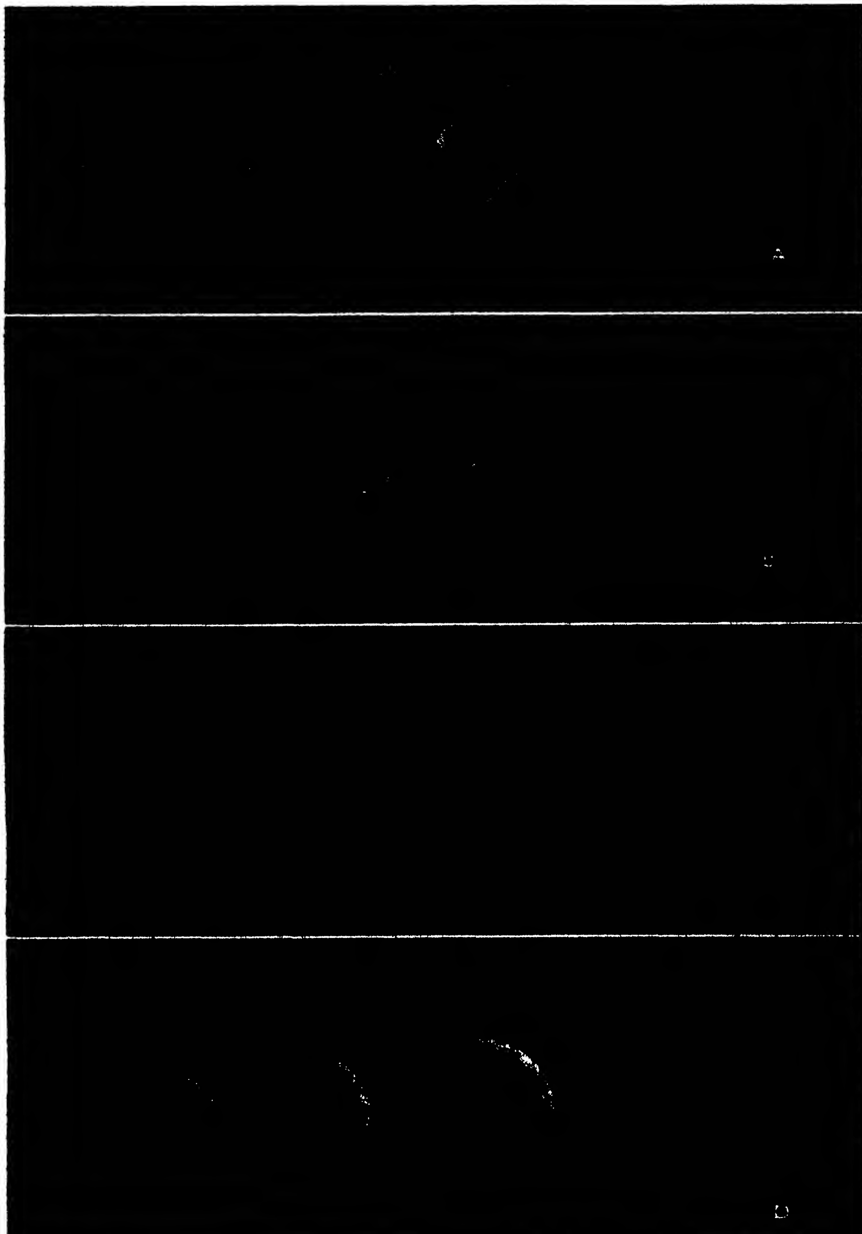


PLATE 30.—Turtle Eggs: The Round Eggs. *A, Amyda mutica. B, Amyda spinifera. C, Chelydra serpentina. D,* Left to right, to show relative sizes: *Amyda mutica, Amyda spinifera, Chelydra serpentina, Macrochelys temminckii.* (The last specimen is the original Agassiz specimen, loaned by the Museum of Comparative Zoology.)

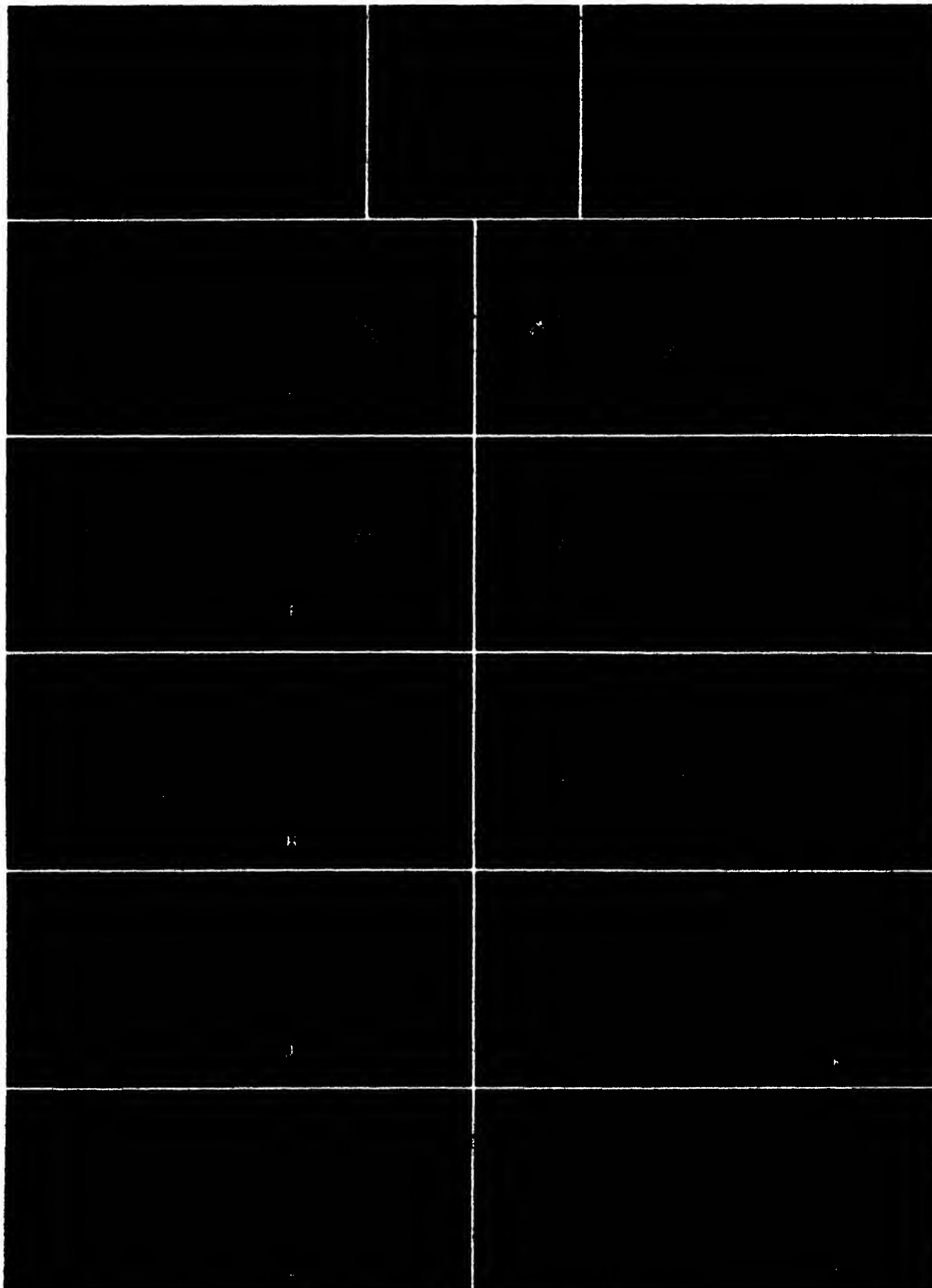


PLATE 31.—Turtle Eggs: The Ovate Eggs. *A, Emys blandingii. B, Kinosternon subrubrum subrubrum. C, Clemmys guttata. D, Sternotherus odoratus. E, Terrapene ornata. F, Chrysemys picta dorsalis. G, Terrapene carolina carolina. H, Pseudemys concinna. I, Chrysemys picta marginata. J, Chrysemys picta bellii. K, Graptemys pseudogeographica pseudogeographica. L, Graptemys geographica. M, Pseudemys troostii.*

Sex Differentiation.—In the male the tail is longer than in the female; the scales on the front legs are coarser and the claws are heavier than in the females. In the adult male the central area of the plastron is concave; in the female this region is either flat or slightly convex, as it is in immature specimens of both sexes.

The wood turtle has never been recorded from Illinois so far as the writer is aware. It is a northern species, which extends in distribution from Maine to Virginia in the east and south, westward to Michigan and Wisconsin and northward into Canada. Ruthven, Thompson, and Gaige (1928) record it from the northern half of southern Michigan. In Wisconsin it is not reported by either Hoy (1883) or Higley (1889), but Pope and Dickinson (1928) report it as "probably state-wide" in distribution, with records from Shawano County (northeastern Wisconsin), Polk County (northwestern), Waupaca County (east central), the upper Wisconsin River (north central), and Waukesha County (extreme south central). It is included in this hypothetical list of Illinois species only on the basis of a specimen taken in the summer of 1933 in Rock County, Wisconsin, by Mr. C. R. Naeser, who presented the specimen to the writer. This turtle was taken from the Rock River south of Janesville, Wisconsin, eleven miles north of the Illinois state line, and is probably a transport. While *Clemmys insculpta* is undoubtedly very rare in southern Wisconsin, if it occurs there at all, the capture of a typical specimen so close to the Illinois line would indicate at least the possibility of its eventually being found in this state. It is one of the very few species that future investigators may perhaps add to the list of native Illinois species.

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GLOSSARY

Abdominal scutes: From the anterior end, the fourth pair of scales of the plastron.

Alveolar surface: The flat masticatory surface of the jaws, lying just inside the cutting edge.

Amphycoelous: A condition of the body (centrum) of the vertebra in which both ends are concave.

Anal plates: The most posterior pair of scutes of the plastron.

Anchylose: A fixed (fused) joint.

Axillary plate: A small plate inserted in the anterior (axillary) margin of the bridge.

Barbel: A short process of skin about the mouth, neck, or chin.

Bridge: The lateral prolongation of the plastron, together with other elements, which meets the carapace.

Callosity: A patch of hard skin on the plastron of soft-shelled turtles.

Carapace: The upper (dorsal) portion of the shell of a turtle.

Carinate: Keeled, or with a sharp ridge.

Choana: The internal opening of the nostrils.

Costal: Pertaining to the ribs; hence: the paired lateral scutes of the carapace.

Costiform: Rib-like.

Cruciform: Shaped like a cross.

Dermal skeleton: The bony skeleton of the shell.

Emarginate: With a broad, shallow notch.

Entoplastron: The only unpaired bony element of the dermal skeleton of the plastron.

Epidermal skeleton: The scale-like shields or scutes which cover the dermal skeleton of most turtles.

Epiplastra: The most anterior, paired bony elements of the dermal skeleton.

Femoral scutes: From the anterior end, the fifth pair of scales of the plastron.

Gulars: The most anterior pair of scutes of the plastron.

Hinge: A ligamentous, flexible joint in the plastron.

Humerals: The second most anterior pair of scutes of the plastron.

Hyoplastra: From the anterior end, the second pair of bony elements of the dermal skeleton.

Hypoplastra: The third most anterior pair of bony elements of the dermal skeleton.

Inframarginals: Secondary scutes lying below (ventral) the marginals.

Inguinal: A small plate inserted in the posterior (inguinal) margin of the bridge.

Intergular: An unpaired element located anterior to the gular scutes in a few turtles.

Keel: A well-defined ridge.

Lobe: The region of the plastron anterior or posterior to the bridge.

Marginals: Scutes forming the lateral margin of the carapace.

Neurals: The middle (unpaired) series of bony elements of the dermal skeleton of the carapace.

Notch: A sharp V-shaped indentation.

Nuchal: The most anterior, unpaired, median marginal scute.

Opisthocoelous: The condition in the body (centrum) of the vertebra in which the anterior face is convex, the posterior face concave.

Papilla: A small fold of the mucous membrane within the nose.

Pectoral scutes: From the anterior end, the third, paired, set of scutes of the plastron.

Plate: A scute; usually designating a heavy scale.
Plastron: The ventral portion of the shell of a turtle.
Procoelous: The condition in the body (centrum) of a vertebra in which the anterior face is concave, the posterior convex.
Pygals: The scutes above the tail; supracaudals; caudal marginals.
Reniform: Kidney-shaped.
Reticulate: Net-like.
Rugae: Small folds; wrinkles.
Scute: A scale; one of the component elements of the epidermal skeleton.
Serrate: Toothed; saw-edge.
Shield: A scute.
Submarginal: Below the marginal scutes.
Supracaudal: Above the tail; the most posterior pair of marginal scutes; caudal marginals; pygals.
Supramarginals: Accessory marginal scutes located above the marginals.
Symphysis: The fixed union along the midline between paired bones.
Temporal arch: A bony bar extending from the quadrate to the upper jaw.
Truncate: Having a square or even edge.
Tubercle: A short, knob-like protuberance.
Vertebral: The median, unpaired scutes of the carapace.
Wing: The lateral prolongation of the elements of the plastron which aid in forming the bridge.
Xiphiplastra: The most posterior paired bony elements of the dermal skeleton of the plastron.

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THE PHYLOGENY OF THE HEMIPTERA BASED ON A STUDY OF THE HEAD CAPSULE

WITH 24 PLATES

BY

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CONTENTS

Introduction 7
Acknowledgments 8
Materials and Methods 8
The Generalized Hemipterous Head 10
Modifications of the Parts of the Head in Homoptera . . 13
Phylogeny of the Homoptera 22
The Generalized Heteropterous Head 24
Modifications of the Parts of the Head in Heteroptera . . 27
Phylogeny of the Heteroptera 37
Summary 41
Bibliography 45
Plates 51

INTRODUCTION

The head of the Hemiptera is a highly modified structure. It is not surprising, after comparing it with the head of a generalized, mandibulate insect, to find that there has been considerable controversy regarding the identity of the various sclerites involved. The problem of the homology of these sclerites was practically hopeless until we obtained some direct evidence from embryology. The early work of Heymons (1899) gave us our first clue. This work was later corroborated and extended by Muir and Kershaw (1911, 1912). Further careful studies of the musculature of the various parts by Muir (1926) and Snodgrass (1921, 1928, 1935) have given us a fairly secure foundation upon which to base comparative studies.

Careful and intensive studies of various species have recently been made: *Nepa,* Hamilton (1931); *Naucoris cimicoides,* Becker (1929); *Psylla mali,* Weber (1929). Nevertheless the head in various Hemiptera has quite a variable structure, and in many cases superficially similar parts have been misinterpreted. It was with the hope of indicating some of these misinterpretations and thereby gaining some indication of the phylogeny of the group that this study was undertaken. It was thought that a study of the nymphs would aid in the understanding of some of the adult structures, and an effort was made to obtain and study as many nymphal forms as possible.

The author is fully aware of the impossibility of showing the true phylogeny by a study of a limited group of characters and of the dangers of misinterpretation involved. There is no intention of claiming finality for the suggestions made. Results will be discussed in relation to the findings of other workers using other sets of characters.

The characteristics presented by the head capsule of the Hemiptera appear to be a particularly valuable record for phylogenetic studies because, throughout the order, there has been little modification of function. Hence the structural differences which accompany changes in function are reduced to a minimum. One or two interesting exceptions to this statement will be described later.

Very little attention has been paid to the mouth parts in this work because they are pretty much of the same pattern throughout the order. The mandibles and maxillae are discussed as a means of identifying the fixed parts of the head. The types of mandibular levers have been studied to determine their phylogenetic value.

The terms applied to the various parts are, so far as possible, those which have been in general use. The general nomenclature of MacGillivray (1923b) or Snodgrass (1935) has been followed. New terms or new applications of old ones have been suggested for parts previously

incorrectly named or where systematists have applied different terms for the same structure in the two suborders.

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This study was begun under the late Professor A. D. MacGillivray, and the author is greatly indebted to him for help and inspiration. It has been completed under Professor W. P. Hayes, and to him, likewise, the author is indebted for constant help and encouragement.

Some of the specimens used in this study were obtained from the collections of the Illinois State Natural History Survey. I am indebted to the late Professor S. A. Forbes and to Dr. T. H. Frison and Dr. H. H. Ross for these courtesies. Among the most interesting of these materials were nymphs of the enicocephalid, *Systelloderus biceps* (Say) and of the ceratocombid, *Ceratocombus vagans* McA and Mal. These were loaned through the courtesy of Dr. Ross and, so far as I have been able to discover, are the first nymphs of these families on record. The author has since taken two specimens of the nymphs of *Ceratocombus vagans* from the University Woods at Urbana, Illinois.

The author also wishes to thank Professor H. B. Hungerford for gifts of specimens of *Naeogeus burmeisteri* L. and S. and *Ochterus viridifrons* Champ. Mr. H. E. McClure kindly furnished some specimens of *Systelloderus biceps*. Mr. Walter Scruggs has spent many hours in arranging and photographing the plates, for which work the author is very grateful.

MATERIALS AND METHODS

Studies were made of representatives of all of the North American families in which material was available. Nymphs as well as adults were studied in every case in which they were obtainable, and this represents a surprisingly large proportion of the families.

The heads were treated in ten per cent caustic potash until they were fairly clear and were then studied under the binocular microscope. It was found that the details were most readily seen in heads that were preserved and studied in glycerine. This had the further advantage of keeping them soft and flexible.

The mandibular levers were dissected from heads that had been thoroughly treated in the potash. The larger forms were then cleared in carbolxylol and mounted in balsam, while the smaller forms were studied in a drop of glycerine.

The following representatives of the various families were studied. The names are those used in Blatchley's *Heteroptera of Eastern North America* (1926), or Britton's *Hemiptera of Connecticut* (1923), or VanDuzee's *Catalog of the Hemiptera of North America* (1917).

HOMOPTERA

FULGORIDAE

Otiocerus degerrii Kby.
Otiocerus wolfii Kby.
Amaloptera uhleri VanD.
Lamenia vulgaris (Fitch)
Cyarda melichari VanD.
Acanalonia sp. nymph
Acanalonia latifrons (Walk.)
Ormenis pruinosa (Say)
Pelitropis rotatula VanD.
Oliarus vicarius (Walk.)
Catonia impunctata (Fitch)
Cixius pini Fitch
Epiptera sp. nymph
Cyrpoptus reineckei VanD.
Liberniella ornata (Stal) nymph
Pentagramma vittatifrons (Uhl.) adult and nymph
Dictyophora florens (Stal)
Bruchomorpha sp. adult and nymph

CERCOPIDAE

Lepyronia quadrangularis (Say) adult and nymph
Monecophora bicincta (Say)

CICADIDAE

Tibicen sayi (Sm. and Grsb.) adult and nymph

CICADELLIDAE

Agallia constricta VanD.
Oncometopia undata (Fabr.)
Gypona sp. nymph
Jassus olitorius Say adult and nymph
Phlepsius excultus (Uhl.)
Erythroneura comes (Say)
Acinopterus acuminatus VanD.
Euscelis bicolor (VanD.)

APHIDIDAE

Lachnus sp.

PSYLLIDAE

Pachypsylla celtidis-mamma Riley
Trioza tripunctata (Fitch)

ALEYRODIDAE

Trialeyrodes sp.

HETEROPTERA

BELOSTOMATIDAE

Belostoma flumineum Say adult and nymph

NEPIDAE

Ranatra americana Mont. adult and nymph
Nepa apiculata Uhl. adult and nymph

NAUCORIDAE

Pelocoris femoratus P. deB. adult and nymph

NOTONECTIDAE

Notonecta sp. adult and nymph

CORIXIDAE

Corixa sp. adult and nymph

GERRIDAE

Gerris marginatus Say adult and nymph
Gerris remigus Say

VELIIDAE

Rhagovelia obesa Uhl. adult and nymph

MESOVELIIDAE

Mesovelia bisignata Uhl.

HYDROMETRIDAE

Hydrometra martini Kirk

NAEOGEIDAE

Naeogeus burmeisteri L. and S. adult and nymph

OCHTERIDAE

Ochterus americanus (Uhler) adult and nymph
Ochterus viridifrons Champ.

NERTHRIDAE

Gelastocoris sp. adult and nymph

SALDIDAE

Lamprocanthia sp. adult and nymph
Pentacora sp.

ANTHOCORIDAE

Triphleps insidiosa (Say) adult and nymph

CIMICIDAE

Cimex lectularius Linn. adult and nymph

REDUVIIDAE

Sinea sp. adult and nymph
Emesa brevipennis (Say) adult and nymph
Melanolestes abdominalis H.-S.

NABIDAE

Nabis subcoleoptratus Kirby adult and nymph

ENICOCEPHALIDAE

Systelloderes biceps (Say) adult and nymph

CRYPTOSTEMMATIDAE

Ceratocombus vagans McA. and M. adult and nymph

MIRIDAE

Miris dolobratus (Linn.) adult and nymph
Adelphocoris rapidus (Say)

LYGAEIDAE

Ischnodemus falicus (Say) adult and nymph
Myodochus serripes Oliv. adult and nymph

PYRRHOCORIDAE

Euryophthalmus succinctus (Linn.) adult and nymph

NEIDIDAE

Neides muticus (Say) adult and nymph
Jalysus spinosus (Say)

CORIZIDAE

Corizus sp. adult and nymph
Harmoestes reflexulus (Say)
Leptocoris trivittatus Say adult and nymph

COREIDAE

Anasa tristis (DeG.) adult and nymph
Acanthocephala terminalis Dallas

ALYDIDAE

Alydus sp. adult and nymph

PIESMIDAE

Piesma cincrea Say

TINGITIDAE

Corythuca ciliata Say adult and nymph

PHYMATIDAE

Phymata sp. adult and nymph

ARADIDAE

Aneurus sp. adult and nymph

PENTATOMIDAE

Brochymena sp. adult and nymph
Euschistus servus (Say)
Euschistus servus (Say) variety
Euschistus euschistoides (Vollenhoven)
Euschistus tristigmus (Say)
Euschistus tristigmus luridus Dallas

CYDNIDAE

Cyrtomenus mirabilis (Perty)

CORIMELAENIDAE

Corimelaena sp.

SCUTELLERIDAE

Stethaulax marmoratus (Say)

THE GENERALIZED HEMIPTEROUS HEAD

The generalized head of the Hemiptera would be one which most nearly approaches the head capsule of the mandibulate insects. Since all of the head types of this order are rather far removed from those of any

existing mandibulate insect, the designation of a generalized type of head is rather difficult.

There are extensive differences between the head structures found in the two suborders Homoptera and Heteroptera. There has been, furthermore, some dispute as to which of the suborders is the more primitive. Some workers, who have arranged the orders in an ascending or descending series, assume that the Heteroptera are the more generalized, Comstock (1915). Others have assumed the opposite and have placed the Homoptera first in their ascending series, Kellogg (1905). Tillyard (1918) states that the Homoptera have retained the more primitive wing form and venation, while the Heteroptera have preserved the more primitive form of head and antenna. Muir (1923) believes that the head of Heteroptera is the more primitive.

The earliest fossil forms, however, belong to the Homoptera with the single possible exception of *Eugereon* described by Handlirsch (1908). Considerable discussion has taken place regarding the affinities of this genus. Tillyard (1921) accepts the decision of Handlirsch that it is a heteropteron while Crampton (1927) expresses his doubt about the matter and gives various reasons for deciding that it is not a heteropteron but is perhaps a forerunner of the Diptera. Judging from the figure reproduced by Crampton in his paper, the writer is inclined to agree with him. If this conclusion is sound, then we are left with the fact that all of the earlier fossil forms are homopterous.

The tentorium, as will be shown later, is much more nearly typical in the Homoptera than in the Heteroptera. Certain other features which will be brought out later in this discussion, bear out the fact, that, with one or two exceptions, the head structures of the Homoptera are of a more primitive type than those of the Heteroptera. Only in the form of the labrum in some of the Heteroptera and in the fact that the gular area is not so reduced as in the Homoptera, does the former appear to be the more generalized form.

The fossil record, the form and venation of the wings, the condition of the tentorium and other head structures lead the writer to consider that the Homoptera retain more of the ancestral characteristics than do the Heteroptera. We look, therefore, for the most generalized form of head capsule among the former group.

Most of the workers on the morphology of the Homoptera have used for their studies one of the cicadas. This is perhaps because of their large size and the availability of material as much as the belief that they represent the generalized type. Most of our knowledge of hemipteran morphology has, indeed, been gained from these studies of the cicadan head, and the structure of other forms has been rather haphazardly compared with that of the cicada. Muir and Kershaw (1911a, 1912),

Muir (1926), Snodgrass (1921, 1928, 1935) and Myers (1928) have all made important contributions to the anatomy of this form.

A study of the members of the Fulgoridae, in its broad sense, indicates to the writer that some of the structures of the heads of members of this family show more primitive characteristics than those of any other family of the Homoptera. The author recognizes the fact that this family contains forms which, in many respects, are highly specialized, but he believes, nevertheless, that many of the structures have been retained in rather primitive form. *Otiocerus degeerii* has been selected to indicate the structures from which the above conclusions have been reached. This species (Figs. 1 and 53) shows the presence of an extensive vertex (Fig. 53, *v*), a large frons (*fr*), a distinct postclypeus (*pc*) separated from the frons by the fronto-clypeal suture (the epistomal suture of Snodgrass 1935), a much smaller anteclypeus (*ac*) which bears a small pointed labrum (*lbr*) attached to its posterior margin. The maxillary plate (*mp*) is large and triangular, tapering to a sharp point, the maxillary process. This plate is separated from the clypeus by a deep suture, and it is near the base of this suture that the mandible is attached. This suture is homologous with the genal suture of Muir (1926) and Myers (1928). It marks in reality the lateral limits of the clypeus and, since the maxillary plate is made up in part of the gena, this term may well be retained for it.

The antafossae (*af*) are located on the front just dorsad of the fronto-clypeal suture. The antafossae, then, are also just dorsad of the point of attachment of the mandibles and may serve as landmarks to delimit the postclypeus in those forms in which the fronto-clypeal suture is wanting. This relation between the antafossae and the point of mandibular attachment has been found to be constant in all of the forms examined. Thus a line drawn across the fronto-clypeal area, slightly ventrad of the antafossae will, approximately, separate the two areas.

The lateral margins of the postclypeus are slightly invaginated along the border of the maxillary plate forming the genal suture. The pretentorinae occur at the base of these sutures. They are located at the bottom of the infolded area and hence are not visible externally.

The anteclypeus is a rather small area with the lateral margins deeply invaginated and the two invaginations, one from each side, meet within the head and form a hollow cylinder which supports the salivary pump and the setae. A long projection extends from the dorso-ventral margin, extending for a considerable distance dorsad into the region covered by the postclypeus (Fig. 346).

The complete absence in *Otiocerus* of those much discussed sclerites, generally designated as the mandibular plates by morphologists and as lorae by systematists, should be noticed. *Otiocerus* is, in this respect,

more primitive than any of the other Homoptera. The gradual development of these sclerites will be shown later in an interesting series of forms. The mandibular attachment is usually described as being on these sclerites but the evidence here shows that the genal suture is the important feature marking the location of these points. The method of development of these sclerites shows them to be undoubtedly parts of the clypeus and the writer favors the term paraclypeus for them in place of the terms mandibular plates or lorae. This term has been suggested for them by Crampton (1921) and the areas have been referred to as parts of the clypeus by Deshparde (1933).

MODIFICATIONS OF THE PARTS OF THE HEAD IN HOMOPTERA

THE VERTEX.—The vertex is here considered in its morphological concept, that is, as including that portion of the epicranium on each side of the epicranial stem and bounded anteriorly by the epicranial arms. These sutures are termed the coronal and frontal respectively by Snodgrass (1935) but the author sees no reason for changing from the former well known terms. A study of the nymphs gives us an idea of the extent of this area. The epicranial stem and arms are not visible in any adult homopteron known to the author.

The term crown has been suggested by Myers (1928) for the dorsal aspect of the head largely because of the incorrect interpretation of the extent of the vertex in the Fulgoridae. Snodgrass (1935) makes this same error but retains the term vertex and states that this area in the Homoptera, particularly in the Fulgoridae, is a very large area and that these forms, in consequence, have a greatly reduced frons. He further states that the peculiar enlargements of the head, so often found in members of this family, are formed entirely by the enlargement of the vertex. A study of the nymphs of these forms indicates that this conclusion is incorrect. These forms, in general, have the vertex limited largely, if not entirely, to the dorsal aspect of the head, and the cephalic aspect of the head contains an extensive frons (Figs. 11, 40, and 41). The processes on the heads of these insects are then made up of extensions of both vertex and frons. This is true of *Scolops* sp. whose nymphs show a very long epicranial stem extending to the apex of the elongation, then dividing into the two epicranial arms which extend down the cephalic surface of the elongation and mark the position of the frontal carinae in the mature insect. In some families of the Homoptera the vertex is rather extensive and the frons is reduced to a very small area (Fig. 23).

Snodgrass (1935) figures the head of *Oecleus borealis* and labels the carinae surrounding the median ocellus as the epicranial arms, and, consequently, the minute area included by them, as the frons. The study of

a cixiid nymph, which the writer succeeded in obtaining only after the plates for this article were made up (and hence it is not figured), shows a rather short epicranial stem with the arms branching out just caudad of the compound eyes, and curving cephalad, paralleling the inner margins of these eyes. Hence the frons is a rather extensive area in these forms. Compare the figure of the nymph of *Epiptera* sp. (Figs. 36 and 63). This is a closely related form.

Reference to figures of the following species will give some idea of the relative extent of the vertex and frons in the various forms. The epicranial stem is comparatively long in such nymphs as the delphacids, *Liburniella ornata* (Fig. 38, *es*) and *Pentagramma vittatifrons* (Fig. 39), as well as in the cicadid, *Tibicen sayi* (Fig. 44); the membracid, *Ceresa* sp. (Figs. 24 and 25); the cicadellids, *Jassus olitorius* (Fig. 47); *Gypona* sp. (Fig. 48); the aphidid, *Lachnus* sp. (Fig. 50); and in the psyllids, *Pachypsylla celtidis-mamma* (Fig. 51) and *Trioza tripunctata* (Fig. 52). It is only moderately long in the cercopid, *Lepyronia quadrangularis* (Fig. 42) and is very short in such forms as *Bruchomorpha* sp. (Fig. 40) and in *Acanalonia* sp. (Fig. 37).

The Frons.—That area of the head capsule bounded dorsally and sometimes laterally by the epicranial arms and ventrally by the fronto-clypeal suture is considered as the frons.

Referring to the remarks made in the discussion of the vertex, we find that this area also varies greatly in size and is not always the greatly reduced sclerite suggested by Snodgrass (1935). As was stated in the description of *Otiocerus degeerii*, the fronto-clypeal suture is wanting in many forms and in these we may use the imaginary line drawn across just ventrad of the antafossae as the ventral limit of the frons.

The frons is very extensive in many of the fulgorids, such as *Otiocerus degeerii* (Fig. 1, *fr*); *Lamenia* sp. (Fig. 2); *Amaloptera uhleri* (Fig. 3); *Cyarda melichari* (Fig. 4); *Ormenis pruinosa* (Fig. 6); *Pelitropis rotatula* (Fig. 7); *Dictyophora florens* (Fig. 15); and *Acanalonia latifrons* (Fig. 18). It is of moderate size in the cercopid, *Lepyronia quadrangularis* (Fig. 20) and the cicadellids, *Oncometopia undata* (Figs. 28 and 49); *Jassus olitorius* (Figs. 29 and 30); *Acinopterus acuminatus* (Fig. 32); and *Erythroneura comes* (Fig. 31). The frons is much reduced in the aphidid, *Lachnus* sp. (Fig. 50) and the psyllids, *Pachypsylla celtidis-mamma* (Figs. 34 and 51) and *Trioza tripunctata* (Fig. 52). In the cicadid, *Tibicen sayi* (Figs. 22, 23, and 44), the membracid, *Ceresa* sp. (Figs. 24 and 25), and the cercopid, *Monecophora bicincta* (Fig. 21), the frons is reduced to an extremely small area.

It is well to call especial attention, here, to the marked difference in the size of the frons in the two cercopids, *Lepyronia quadrangularis* (Fig. 19) and *Monecophora bicincta* (Fig. 21).

THE CLYPEAL REGION.—This region always consists, in the Homoptera, of at least two parts, and in the great majority of forms, of four parts. The statement made by Snodgrass (1935) that in some species of Fulgoridae, the clypeus consists of a single piece is incorrect. He cites *Oecleus borealis* as an example. The division between the anteclypeus and postclypeus is, in this form, obscured by a strongly elevated carina extending vertically down the frons and clypeal region. The lateral aspect of this region, however, shows a clear separation between the two areas and this division is still more readily seen in specimens that have been treated in caustic potash. The paraclypeus is also present in this form.

The anteclypeus and postclypeus are always present in the Homoptera, and in the majority of forms there is a more or less well developed paraclypeus on each side.

This divided condition of the clypeus is commonly found in some of the lower insects, such as the Orthoptera. Crampton (1921) refers to these areas as the postclypeus and the anteclypeus. He also describes the lateral areas of this region as found in the larva of *Corydalis* and applies the term paraclypeus to them. These areas were termed the antecoxal piece of the mandible by Comstock (1925) and the clypealia by MacGillivray (1923b). Crampton (1921) suggests that, in these insects, these areas are formed by the extension of the epicranial arms across the clypeus. This is not the method of their formation in the Hemiptera, and they can therefore not be homologous structures, but the writer has used the term paraclypeus to designate them.

The postclypeus (*pc*) is usually a large and well defined area. It furnishes the attachment plane, internally, for the muscles of the pharyngeal pump. In many forms it is distinctly separated from the frons by the fronto-clypeal suture, as in *Otiocerus degeerii* (Fig. 1); *Catonia impunctata* (Fig. 9) and *Tibicen sayi* (Fig. 23). This suture is wanting in the cercopid, *Lepyronia quadrangularis* (Fig. 20), the membracid, *Carynota mera* (Fig. 26) and in all of the cicadellids (Figs. 27-32). The position of the antafossae (*af*) gives us the clue to the extent of the paraclypeus in these forms. The places of attachment of the pharyngeal muscles also aids in locating its anterior limits.

The greatly reduced frons in the cicada and the enormous enlargement of the postclypeus has resulted in a great deal of discussion as to the homology of these parts. Vickery (1908) called the postclypeus the clypeus, Meek (1903) labelled it the frons, while Berlesi (1909) recognized two areas and called them postfrons and frons. Muir and Kershaw (1911) returned to the term clypeus, Branch (1914) recognized it as the frons as did Snodgrass (1921) and Muir (1926). The latter suggested that it might be a clypeofrons. Snodgrass (1921) demonstrated, by a study of the muscle attachments that it was clearly clypeal in nature and

termed it the postclypeus. Myers (1928), however, still refers to it as the frons.

The postclypeus, in those forms which lack the paraclypeus, is bounded laterally by the genal sutures. These margins are somewhat invaginated and from the ventral portions of these invaginations, wing-like projections extend to the pharyngeal pump which they help to support.

Where the paraclypeus is well developed, the anteclypeus is marked off by a deeply invaginated suture on each side. These are the frontal sutures of Muir (1926), Myers (1928) and Snodgrass (1935). They are not extensions of the epicranial arms, as will be shown later, and hence should hardly be termed the frontal sutures. The invaginations along these sutures form a deep flange about the postclypeus, extending into the head, which serves for muscle attachment and from the ventral margins of which there extend wing-like supports to the pharyngeal pump.

The anteclypeus (*ac*) is a small but well defined area attached to the ventral margin of the postclypeus. The lateral margins are more or less invaginated and sclerotized, ranging from the strongly sclerotized cylinder of *Otiocerus wolfii* (Fig. 346) to the nearly membranous and flattened areas found in cicada. These invaginations serve as supports for the salivary pump and for the mesal margins of the mandibular and maxillary setae.

The paraclypeal regions make up the areas which have occasioned the greatest discussion of any part of the hemipterous head. They have been called the lorae by systematists for many years. Smith (1892), in discussing the morphology of the cicada, stated that they were derived from the mandibular segment and hence referred to them as the mandibular plates. Muir and Kershaw (1911a) described these areas as extensions of the clypeus, and the same authors (1912) stated that they were not formed from the mandibular sclerite and had no relation to the mandibles. They declared them to be homologous with the gena of other orders. Muir (1926) declared them to represent a part of the genal area. He states, in this same work, that there is no embryological evidence that they are parts of the mandibular segments. Snodgrass (1927) agreed with this conclusion but later (1935) again refers to them as the mandibular plates. Myers (1928) homologizes them with the gena and states that they are not lateral clypeal sclerites nor mandibular plates; Weber (1929) calls them the laminae mandibulare, while Deshparde (1933) refers to them as clypeal sclerites.

Examination of the drawings of the head of *Otiocerus degeerii* (Fig. 1) and of *Lamenia sp.* (Fig. 2) shows that the paraclypeal areas are wanting. The anteclypeus is attached, with a very slight indentation, to

the ventral margin of the postclypeus. The drawing of *Amaloptera uhleri* (Fig. 3) shows the anteclypeus included for a considerable distance within the postclypeus, cutting off a small area on each side which may be regarded as the beginning of the paraclypeus (Fig. 3, *pac*). A study of a series of forms such as *Cyarda melichari* (Fig. 4), *Acanalonia latifrons* (Fig. 18), *Pelitropis rotatula* (Fig. 7), *Epiptera* sp. (Fig. 11), and *Bruchomorpha* sp. (Fig. 16) shows in the order named progressive steps in the inclusion of the paraclypeus by the postclypeus and hence the increasing size of the paraclypeal areas.

Muir and Kershaw (1912) state that the embryonic development of the Hemiptera shows there is an extension or overgrowth of the areas referred to by them as the genae and the maxillary plates. This satisfactorily explains the conditions found in such forms as the cercopid, *Lepyronia quadrangularis* (Fig. 20), the membracid, *Carynota mera* (Fig. 26) and others in which the distal ends of these areas extend well beyond the point of union between the postclypeus and the anteclypeus. The paraclypeal areas in some forms have become entirely vertical and are visible only from the lateral aspect, as in *Catonia impunctata* (Figs. 9 and 61).

The study of this series leaves little doubt that the paraclypeal areas are actually portions of the clypeal area cut off by the progressive development of a suture extending from each proximal corner of the anteclypeus. This suture is the one referred to by Muir (1926) as the frontal suture.

THE MAXILLARY PLATES.—The origin of these plates (*mp*) from a part of maxillae in the embryo was first described by Heymons (1899) and corroborated by Muir and Kershaw (1911 and 1912). The terminology of these plates has since been quite uniform. MacGillivray (1923b) refers to them as the hemimaxillae.

These areas, in addition to a portion of the maxillae, undoubtedly include, at least in part, the genae and postgenae. Snodgrass (1921) makes the statement that they are largely postgenae. There are traces of sutures, in some forms, which may indicate the line of fusion of the maxillary area with the postgenae. These sutures have been termed the maxillary sutures by Muir (1926). They are very faint and have been indicated by dotted lines in the drawings of *Euscelis bicolor* (Fig. 82) and of *Monecophora bicincta* (Fig. 71).

Muir (1926) also recognizes a fourth suture, the labial suture, along which the invaginations (metatentorina of MacGillivray 1923b) of the metatentoria occur. The writer has not been able to find these sutures in the forms studied. They may be the line of attachment of the labial membrane to the postgenae or they may represent the postoccipital sutures of Snodgrass (1935).

The maxillary plates form most of the lateral and caudal aspects of the head. They enclose the maxillary and mandibular setae and lend support to them. They become narrower ventrally and end in a sharp point which has been termed the maxillary process. These processes support the labium, especially when the insect is in the act of feeding. The maxillary plates vary greatly in size and shape throughout the group. (Figs. 53-86, *mp*).

THE LABRUM.—This is a small, narrow, triangular sclerite attached to the ventral margin of the anteclypeus. It lies along the base of the groove of the labium, partially covering this groove and lending support to the mandibular and maxillary setae. It varies somewhat in length but is otherwise quite uniform in the Homoptera.

There has been some discussion in regard to the composition of this sclerite. It has frequently been referred to as the epipharynx (Crawford 1914). Muir and Kershaw (1911a) state that "The division between the labrum and the epipharynx is obscure" and suggest the term labrum-epipharynx for it. MacGillivray (1923b) and Myers (1928) follow this terminology. Snodgrass (1935) calls it the labrum.

The epipharynx, in mandibulate insects, is the inner surface of the labrum. In certain sucking insects, as the Diptera, there is evidence of a projecting outgrowth of this inner lining which is visible externally and which may be differentiated from the labrum. There is no such evidence in the Homoptera and, hence, there is no more reason for referring to this sclerite as the labrum-epipharynx in the Homoptera than there is in the mandibulate insect.

THE CAUDAL ASPECT OF THE HEAD.—This area of the head in the Homoptera is almost entirely membranous. The lateral and ventral borders of the large occipital foramen (*oc*) are formed by the occiput which is fused with the vertex without evidence of a suture.

The postoccipital area is membranous, and it is very difficult or impossible to determine the exact division between it and the neck membrane. Odontoidea are seldom distinguishable. Their position is indicated by the occurrence of the metatentorinae (Fig. 91, *mt*). The metatentorinae are externally visible in very few species.

There is no gula or gular area in this suborder. The labium is joined to the maxillary plates by membrane.

THE TENTORIUM.—The tentorium of the Homoptera is very nearly typical. A good deal of discussion has occurred in regard to this structure, and the fact that some secondary structures occur has resulted in some confusion. Muir (1929) states that the anterior arms of the tentorium are invaginated from the hypopharynx and hence cannot be homologized with those of other insects nor should they be used as landmarks of the fronto-clypeal suture. He further states that this is similar

to conditions found in the Myriapoda and the Apterygota and hence indicates a more primitive origin than was previously supposed for the Hemiptera. The author does not understand just what Muir has in mind and does not agree with the conclusions. Snodgrass (1928) points out the homology of the tentorium of all insects with the hypopharyngeal apophyses of the Myriapoda but states that the "final condition is characteristic of all Pterygota except the Ephemerida and Odonata." This of course implies the homology of the tentorium of the Hemiptera with that of the mandibulate insects.

The tentorium of the members of the Cercopidae appears to be the most nearly typical of any of the Homoptera. The metatentoria (posterior arms) are invaginated from the membrane, on each side, about at the middle of the occipital foramen (Figs. 100 and 102, *mt*). These metatentorinae supposedly mark the position of the post-occipital suture and of the odontoideae, but neither of these structures are distinguishable in these forms.

The metatentoria extend mesad and unite to form the corpotentorium (body of the tentorium). This appears as a narrow, cylindrical bar, extending across the occipital foramen (Fig. 102, *ct*). A broad, heavily sclerotized plate extends ventrad from each corner of the corpotentorium. The plates merge with the evaginations of the hypopharynx. These wings of the hypopharynx are perhaps the "invagination of the hypopharynx" referred to by Muir (1929). They are clearly secondary in nature and have become united with the tentorium proper during the evolution of the group. They serve as supports for the pharyngeal pump and as guides for the maxillary and mandibular stylets.

Two narrow rods may be observed extending dorsad, one from each side of the meson of the corpotentorium. Near the cephalic ends of these rods each divides into two branches. The branch nearest the meson extends to a point at the base of the genal suture, ventrad of the antafossae where may be found the opening of the invagination which is a pretentorina. The rods in question represent the pretentoria (Fig. 102, *pt*). The lateral branch, extending cephalo-laterad from each pretentorium, probably represents the supratentorium (the dorsal arms) (Fig. 102, *st*). This branch extends forward until it comes in contact with the head capsule where it may become lightly attached. There are no external signs of invagination on the head, for these structures and their position agrees with the account of the supratentorium given by Riley (1904). This author states that the supratentorium in *Blatta* appears as an outgrowth from the pretentorium and that they are not independently invaginated. Nelson (1915) corroborates these findings in the honey bee, *Apis*.

The tentorium in *Lepyronia* (Figs. 101 and 102) and in *Monecophora* (Fig. 100) consists of all of the parts found in the head of generalized

insects and they are formed in the normal manner. There are two pairs of invaginations, the pretentorina and the metatentorina, which occur in relatively the same positions and serve as landmarks for the same sclerites as they do in the mandibulate insects.

The head of the cicadid, *Tibicen sayi* (Figs. 104 and 105), has the same type of tentorium except for the lack of the supratentoria. The Fulgoridae also lack the supratentoria, and there is a great variation in the degree of sclerotization of the pretentoria (Figs. 87-95). Many of these are so lightly sclerotized at the cephalic ends as to be easily pulled free from the head, and one may mistakenly consider them to have been entirely free from the head capsule.

The Membracidae have a somewhat reduced tentorium. There is no evidence of the pretentorial arms in *Ceresa sp.* (Figs. 106 and 107) nor in *Carynota mera* (Fig. 103). In the latter species, the dorsally projecting point at each end of the corpotentorium might be considered a remnant of the pretentorium, but it is not in the normal position and it is difficult to conceive of the structure surviving at the point farthest from the place of invagination. The tentorium of these forms is otherwise similar to that found in the Cicadidae. The loss of the pretentorium may have accompanied the decided deflection of the head, so that the antafossae are located directly beneath the corpotentorium when the head is in its normal position.

Another unusual condition is found in the tentorium of the Cicadellidae. In these forms, the metatentorium and corpotentorium are similar to those described in the preceding families. There are, however, no pretentorial arms attached to the corpotentorium. There does occur, just ventrad of each antafossa, an extensive apodeme which extends dorsad and ends without attachment of the distal end to the head capsule.

These apodemes, in *Jassus olitorius* (Figs. 109 and 110, *ap*) and in *Acinopterus acuminatus* (Fig. 111, *ap*), are long and straight. They are branched in *Euscelis bicolor* (Fig. 112), *Phlepsius excultus* (Fig. 113), and *Oncometopia undata* (Fig. 114). Notice that this branching occurs well toward the distal end of the apodeme in the first two species, while in *Oncometopia* it occurs almost at the point of invagination. The author was unable to find any trace of these apodemes in *Erythroneura comes* (Fig. 115).

The homology of these apodemes is in doubt. One is tempted to refer to them as the pretentoria. They originate at the place at which the pretentorina generally occurs. If they are homologous with the pretentoria then the branches would be the supratentoria. The author has not found any reference to pretentoria which do not connect with the corpotentorium. They have, therefore, been referred to simply as apo-

demes in this work. Embryological studies or the examination of a large range of species might throw some light upon this problem.

The psyllid, *Pachypsylla celtidis-mamma,* possesses a tentorium which resembles in form that of the cicada. It differs in the fact that the corpotentorium is shorter and that the pretentorial arms are heavier and more firmly united with the head capsule. The aphid, *Lachnus* sp., likewise resembles the cicada in the structure of the tentorium, excepting that the pretentorial arms extend from the corpotentorium at such an angle that they are hidden by the corpotentorium when the head is examined from the caudal aspect.

It is of interest, here, to consider the family Peloridiidae. This is a small family of subantarctic Hemiptera about which there has been much discussion as to its systematic position. It was placed in the Heteroptera originally and Kirkaldy (1906b) included the species in the family Ochteridae. China (1924) suggests that it form a new suborder between the Homoptera and Heteroptera. Myers and China (1929) made a thorough study of the external anatomy of *Hemiodoecus leai* and conclude that the family belongs to the Homoptera and that "it is very near the ancestral stock of the two suborders." A study of their figures shows that the tentorium in this species is typically homopterous and is quite similar to that of some of the Fulgoridae.

The Labium.—Very little attention has been paid to the labium in this study. The pattern, throughout the suborder, is quite uniform. Myers (1928) states that the labium consists of three segments with signs of a fourth. The vast majority of forms possess an apparently three-segmented labium. Oestlund (1918) describes a five-segmented labium for the tribe Lachnini of the Aphididae and considers this condition to be the primitive one for the family. Vickery (1908) figures this type of labium. A six-segmented labium was described for the tropical fulgorid, *Pyrops candelaria,* by Kershaw (1910).

The labium in the Homoptera is attached apparently directly to the neck membrane just behind the ventral corners of the maxillary plates.

The Mandibular Levers.—The mandibular stylets, in the Homoptera, are attached to the head capsule by means of a sclerotized plate which is formed by invagination of the upper end of the genal suture and known as the mandibular lever. One end of this lever is attached to the head near the end of the genal suture, just ventrad of the antafossae. The distal end of the lever is attached to the end of the mandibular stylet. A simple type of this lever is seen in *Otiocerus degeerii* (Fig. 350, *1*). The lever in this species joins the mandibular stylet at an acute angle (Fig. 350a, *1*). The shape of the head influences the length of the lever and the angle at which it joins the mandibular stylet.

The cicadid, *Tibicen sayi* (Fig. 352), shows a form in which the base of the mandibular stylet is forked. One fork uniting with the lever (*1*), the second fork extending dorsally into the head and giving attachment to the retractor muscles which arise on the dorsal wall of the head.

This forked condition of the base of the mandibular stylet is also seen in the cercopid, *Lepyronia quadrangularis* (Fig. 351). In this form, the inner fork seems to connect with the base of the maxilla as well as with the retractor muscles. The inner fork is much reduced in *Oncometopia undata* (Fig. 353), being little more than a tendon attaching the retractor muscles. The lever in this species is bent, forming almost a right angle.

The author found no evidence of a mandibular lever in *Pachypsylla celtidis-mamma*. Weber (1929) states that it is absent in *Psylla mali*. The lever, then, may be characteristically wanting in the *Psyllidae*.

The Maxillary Lever.—The maxillary stylet of the cicada is also attached to the head capsule by means of a lever which is more nearly like the mandibular levers of the Heteroptera than are those of the mandibles of the Homoptera. This structure has not been studied in the other families of the Homoptera. It is lacking in the Heteroptera. The place of attachment of the maxillae varies considerably in the different forms; hence they cannot well be used as landmarks for the head sclerites and, therefore, they have been omitted from this work.

PHYLOGENY OF THE HOMOPTERA

These studies on the head capsule have brought to light a number of points which may be of significance in a study of the phylogeny of the group. A brief summary of the present classification may be of service.

The Homoptera was first divided into the series Auchenorhyncha and Sternorhyncha by Amyot and Serville (1843). Duméril (1806) had already proposed the term Auchenorhyncha. These series were based upon the position of the mouth parts and are still in good standing.

The families recognized as belonging to the Auchenorhyncha, arranged in a generally accepted ascending order are, the Cicadidae, Cercopidae, Membracidae, Fulgoridae, and Cicadellidae. A few years ago there was a tendency among students of these insects to break up the Fulgoridae and Cicadellidae into a number of families. Recent workers, however, have returned to the older classification and Britton (1923) lists the five families given above. European workers, Muir (1923), still split the Fulgoridae into some fourteen families.

The Sternorhyncha is composed of the families Psyllidae, Aphididae, Aleyrodidae, and Coccidae. Few changes have been made in this arrangement through the years. Each family forms a distinct and rather homogeneous group.

The author has already stated that he considers the Fulgoridae to have retained some of the most primitive conditions in the structure of the head capsule. It should be emphasized that this family represents quite a varied assortment of insects, many of them highly specialized in certain respects. The splitting of this group into numerous families is probably justified but should await careful morphological studies of representatives of the group from all over the world.

Most workers have considered the Cicadidae as most primitive, while Myers and China (1929) suggest the recently discovered family, Peloridiidae, as representing the most primitive living forms. The author has not seen specimens of this family and cannot express an opinion upon it. Muir (1923) states that "some writers derive the Psyllidae from a psocid-like ancestor and so we must consider all the other Homoptera and Heteroptera as derived from the Psyllidae. In my opinion this is a reverse of the truth."

The same author in his diagram of the affinities of the Homoptera, derives the Fulgoridae very early from his Protohomoptera—in fact it is the first branch to leave the main homopteran stem.

The developmental series of the paraclypeal areas described in the Fulgoridae indicates a very primitive condition in some of these forms. Certain structural resemblances to the Heteroptera, which will be discussed in detail later, add evidence for this conclusion.

We find, on comparison of the heads of *Tibicen sayi* (Figs. 23 and 72), *Oncomctopia undata* (Figs. 28 and 79), and *Moneccophora bicincta* (Figs. 21 and 71) a striking similarity in form and structure. All three of these species agree in having a greatly reduced frons and an enormously enlarged postclypeus. *Moneccophora* differs markedly in this respect from *Lepyronia quadrangularis* (Figs. 19, 20, 69, and 70). *Oncometopia,* on the other hand, differs in the same degree from the other members of the Cicadellidae studied (Figs. 27, 29, 30, 31, 32, 77, 80, 81, 82, 83, and 84).

These facts indicate that perhaps the group represented by *Oncometopia* was derived from the subfamily Cercopinae of the Cercopidae, which includes *Monecophora,* while the other members of the Cicadellidae arose from the subfamily Aphrophorinae, which includes *Lepyronia.* These forms would then represent two distinct families. Oncometopia and its allies has, at times in the past, been separated from the Cicadellidae, placed in a separate family, and known under different names. The name Tettigonidae was applied to this group by Uhler (1875) and Tettigoniellidae by Melichar (1905). Recent writers have reduced this group to subfamily rank.

The adult aleyrodid (Fig. 35) shows closer relationships to some of the Cicadellidae than to the Psyllidae or Aphididae, as far as head

structure is concerned. The latter two groups, characterized by lack of sclerotization of considerable areas of the head capsule, are, thereby, sharply separated from the rest of the Homoptera. Other characters must be considered to obtain any ideas of relationships in the Sternorhyncha. Weber (1929) has discussed these at some length but leaves the question still open.

Kershaw and Muir (1922) studied the genitalia of the Auchenorhyncha and recognized three types of male genitalia: (1) the cercopid type found also in the Membracidae and Cicadellidae, (2) the cicadid type, and (3) the Fulgoroidea type. The last section they further divided into three groups, all developments of the cercopid type. This evidence tends to show the primitive character of the Cercopidae which is also borne out by the present study of the tentorium.

The thoracic sclerites were studied by Taylor (1918). He grouped the Cicadidae and Cicadellidae with the Aphididae and Psyllidae as having similar thoracic structures. The Membracidae stand alone with a specialized prothorax and the Cercopidae, Fulgoridae, and Aleyrodidae are grouped together because of similarly fused metathoracic sclerites.

Two superfamilies of the Auchenorhyncha were recognized by Muir (1923): the Cicadoidea, which possessed antennae with very few sense organs on the flagellum, and the Fulgoroidea, whose antenna possessed many such organs. The structure of the ovipositor, as pointed out in this same paper, overlaps these antennal characters somewhat. He further states that the Cixiidae, considered as a subfamily of the Fulgoridae in this work, possesses the most normal and primitive wing venation of any recent homopteron.

Kirkaldy (1906a) uses the method of oviposition as a basis of dividing the group. He cites the fact that the insects of the Poekillopteridae and Issidae, here recognized as subfamilies of the Fulgoridae, deposit their eggs externally while the Cicadidae, Cercopidae, Cicadellidae, Membracidae, and in part the Fulgoridae deposit them more or less internally. This, perhaps, is further evidence of the primitive position of some of the Fulgoridae.

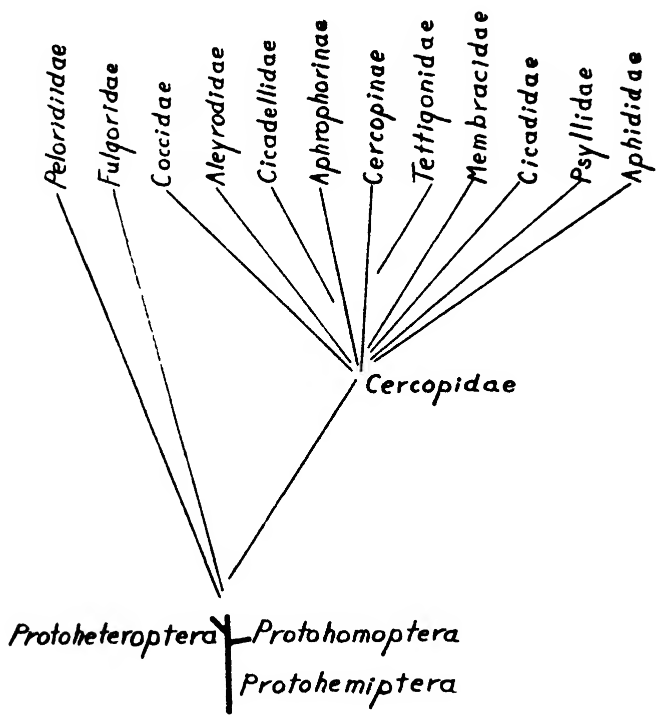
These attempts at unravelling the evolution of the Homoptera are all the writer has been able to find. They show that we are still a long way from the end of the road.

The accompanying diagram (Text-figure 1) gives an idea of the conclusions regarding the relationships of the families arrived at by a study of the head capsule.

THE GENERALIZED HETEROPTEROUS HEAD

The problem of selecting a generalized type of head structure for the Heteroptera is beset with the same difficulties found in the study of the

Homoptera. There is a high degree of specialization in all of the forms, and hence considerable difficulty is experienced in selecting characters which might show progressive development. The outstanding difference in head structure between the Homoptera and the Heteroptera is in the presence of an extensive gular area in the latter group. Students who accept the fossil form *Eugereon* as a primitive heteropteron (Tillyard, 1921) consider that the mouth opening in this group was originally directed cephalad. Consequently the ventral direction of the mouth opening



TEXT-FIGURE 1

becomes a specialized character. No consistent series can be based on this character. It seems to be correlated with feeding habits, the predaceous forms having the more nearly cephalic mouth opening.

Assuming that the Heteroptera originated from a stock common to the Homoptera or as an offshot of the Homoptera, we would expect the size of the gular area to indicate relationships. The shorter the gular area, the more primitive the head structure would be. Here again we find difficulty in arranging the existing forms in any logical series based on this character.

Ekblom (1926) considers the Saldidae as representing the most primitive of living Heteroptera. He bases his conclusions on the short gular area, the ventrally directed mouth, and what he terms the primitive feed-

ing habits, primitive habitat, and methods of egg laying. The writer agrees that the Saldidae are comparatively primitive in head structure and are near the generalized type but he cannot agree with the reasons advanced by Ekblom. Surely the habit of probing the sand for food is not a primitive method of obtaining food nor is the shore line a primitive habitat for insects. Most students consider that insects were originally terrestrial animals and that the present day aquatic and semi-aquatic species are specialized from terrestrial forms and are not generalized forms on the way to a land environment.

A comparative study of the head capsule of the various families of Heteroptera has lead the writer to select two external structures as a guide in selecting the primitive forms and arranging the families in a series. An internal character bears out his conclusions in some cases. Other characters are needed to further subdivide the group. Based upon the study of the Homoptera in which we considered the lack of the paraclypeal areas as a primitive condition, the form of these areas in the Heteroptera is taken as an excellent character which can be used to show successive steps of modification. The second character used in grouping the various families is found in the form of the labrum. This structure, in some species is broad and flap-like (Figs. 152, 155, and 157). It is very similar to that found in most mandibulate insects. This is considered as a generalized form, and the progressive changes to the long slender triangle found in many forms (Figs. 177 and 179) indicates specialization.

Cimex lectularius (Figs. 152, 154, and 237) shows the most primitive combination of these two characters. Objections may be made to the consideration of a parasitic form as a typical or generalized type. However, the writer believes that *Cimex* is a primitive form rather than a degenerate one. Notice the eyes which consist of a scattered group of ocelli. Surely this is a primitive condition. We could consider the loss of the compound eyes as a retrogression accompanying the parasitic habit but we hardly look for a return to the primitive scattered ocelli as such a process. This is certainly the retention of a primitive condition. The writer, however, does not insist too strongly on the acceptance of this form as the most primitive one in the Heteroptera. The members of the family Anthocoridae have equally generalized characteristics, and *Triphleps insidiosa* has been chosen for the description of these primitive characters. (Figs. 158, 239, and 240). The saldid, *Lamprocanthia* sp. also very closely approaches this form in simplicity (Figs. 156 and 238), but for reasons which will be considered later the writer prefers the anthocorid as the most generalized type. Both of these forms show the small paraclypeal areas and the broad, flap-like labrum which have been taken to represent the least specialized condition found in this suborder.

• A description of the head capsule of *Triphleps insidiosa* (Figs. 157, 158, 239, and 240) is given as the generalized type. The epicranial stem and arms are distinct in the nymph (Fig. 157, *es, ea*). Each arm extends laterad to the compound eye and parallels the mesal margin of the eye for at least half the length of the eye. These sutures divide the vertex from the frons and mark the caudal limit of the frons as approximately in line with the caudal margins of the compound eyes.

The fronto-clypeal suture is not present, and this fact leaves some doubt as to the exact extent of the frons. The attachments of the mandibular stylets are located, as they are in the Homoptera, near the ends of the genal sutures just below the antafossae. The line between these points, marking the position of the fronto-clypeal suture, must be arched caudad in *Triphleps* so as to miss the anteclypeus. Just how great this arching is is difficult to say, and it is possible that in some forms the postclypeus has been entirely cut into two lateral areas by the retreat of the so-called frontal sutures.

The anteclypeus (*ac*) is a rather narrow area extending cephalad from the postclypeus. Its lateral margins are deeply invaginated. This area is called the tylus by systematists. There is no suture between the postclypeus and the anteclypeus in *Triphleps*.

The paraclypeal areas (*pac*), termed the jugae by systematists, extend, one on each side of the anteclypeus, for about one-half the length of the anteclypeus. The cephalic half of the anteclypeus is bounded on each side by a maxillary plate (*mp*). The labrum (*lbr*) is a broad, flap-like sclerite attached to the cephalic end of the anteclypeus. The lateral and ventral aspects of the head are formed by a solid sclerotized area without sign of sutures. This area is made up of the maxillary plates, the genae, postgenae, and a sclerotized gular area. There are no landmarks present to indicate the extent of any of these parts.

MODIFICATIONS OF THE PARTS OF THE HEAD IN HETEROPTERA

The Vertex.—The size of this area varies considerably with the shape of the head. The epicranial arms are visible in all of the nymphs examined. The epicranial stem varies from very long in *Sinea* sp. (Fig. 160) to very short in such forms as *Gerris marginatus* (Fig. 136), *Pelocoris femoratus* (Fig. 125), and *Corixa* sp. (Fig. 133). It is entirely wanting in *Aneurus* sp. (Fig. 206) and *Brochymena* sp. (Fig. 208). The epicranial arms branch out at some point caudad of the cephalic margins of the compound eyes, usually near the posterior margin as in *Sinea* sp. (Fig. 160, *ea*), *Nabis subcoleoptratus* (Fig. 165) and *Euryophthalmus succinctus* (Fig. 178). The branching occurs further cephalad in *Emesa*

brevipennis (Fig. 162). The vertex is rather extensive in these forms; but in *Cimex lectularius* (Fig. 153) and *Ischnodemus falicus* (Fig. 175) the arms branch well behind the eyes and the vertex is much reduced. The vertex is limited to the lateral portions of the head capsule in *Aneurus* sp. (Fig. 206) and *Brochymena* sp. (Fig. 208).

The shape of the head seems to control this character, and it varies frequently within the limits of a single family.

THE FRONS.—This area varies inversely with the variation of the vertex described in the preceding section. Those forms with a large vertex have a comparatively short frons. The area also varies with the position of the postclypeus. The fronto-clypeal suture is never present in the Heteroptera. The antafossae serve as landmarks to locate this suture, but due to a pushing back of the clypeal region, accompanied by the curving of the fronto-clypeal line, the anterior limit of the frons is difficult to determine. It is possible that in some cases the clypeal region has been so pushed caudad as to cut the postclypeus completely in two. Pharyngeal muscles are attached in this area, however, which is evidence of its clypeal nature. Weber (1930), in his very excellent book on the Hemiptera, gives figures of the longisections of the heads of an aradid and of the reduviid, *Reduvius personatus,* in which he shows the pharyngeal muscles attached to the head capsule caudad of the anteclypeal area. He also recognizes the presence of the anteclypeus and postclypeus. We cannot recognize any external limits to the cephalic margin of the frons.

The position of the antafossae (*af*) varies greatly within the suborder. This fact has been extensively used as a character to divide the group. The divisions Cryptocerata and Gymnocerata were made on this basis, but, recently, doubt has been expressed as to the phylogenetic value of this character and these subgroups have been abandoned. Reference to the figures will show that they may occur in almost any position. They may be covered by antennal shelves, hidden in pits, or placed on prominent tubercles. The most interesting fact is that with all this migration of the antennae we find that the mandibular levers maintain their point of attachment at the base of the genal suture which somehow arrives at a point near the antafossae in all species. Hence they retain their value as landmarks as they did in the Homoptera.

THE CLYPEAL REGION.—Four areas can be recognized in this region in most forms, and they are homologous with the same areas in the Homoptera. They are the postclypeus, the anteclypeus, and the two paraclypeal areas.

The caudal margin of the postclypeus cannot be determined exteriorly, as was discussed in the previous section. Its cephalic margin is seldom marked by a suture between it and the anteclypeus. Such a suture, however, can be observed in *Myodochus serripes* (Fig. 183) and in *Neides*

muticus (Fig. 185), although it does not appear in the nymphs of these forms (Figs. 181 and 184) and may be a secondary development. It occurs in both nymph and adult of *Phymata* sp. (Figs. 202 and 203). The postclypeus is a very limited area in some forms, and, as was pointed out above, it is perhaps entirely divided in some of the more specialized species. Usually without definite caudal or anterior boundaries it is a rather vague area in this suborder which has lead to the frequent statement that it is absent or that the clypeus consists of a single piece (Snodgrass (1935) and MacGillivray (1923)). Muir and Kershaw (1911) describe the early fusion of the frons with the clypeus in the embryo of the reduviid, *Pristhescancus papuensis.* No trace of a suture remains. However, these authors refer to the anteclypeus as the labrum and to the labrum as the epipharynx. This indicates that the clypeus consists of two parts in the embryo and that the postclypeus fuses with the frons.

The anteclypeus, the tylus of systematists, is a well marked area in nearly all of the species of the Heteroptera. Its lateral margins are deeply invaginated along the so-called frontal sutures. The invagination from each side goes deeply into the head and meets the one from the opposite side and fuses with it. This forms a heavily sclerotized cylinder similar to that described for the homopteron *Otiocerus wolfii* (Fig. 346). The mandibular and maxillary stylets pass through this tube, and it also houses the salivary pump. It is found in nearly all of the Heteroptera (Figs. 347 and 348). The anteclypeus of *Corixa* sp. (Figs. 134 and 135) is of interest because of the widening of the distal margin and a turning up of the disto-lateral angles. This gives this sclerite a shape which is quite unique among the Hemiptera. A much less extensive broadening of the distal margin is seen in *Cimex lectularius* (Fig. 154) and in *Lamprocanthia* sp. (Fig. 155).

Four families of the Heteroptera are without a definitely marked anteclypeus. These families are the Naucoridae, *Pelocoris femoratus* (Figs. 125, 126, 127, and 128), Notonectidae, *Notonecta* sp. (Figs. 130 and 131), Ochteridae, *Ochterus americanus* (Figs. 147 and 149), and the Nerthridae, *Gelastocoris* sp. (Figs. 148, 150, 298, and 299). Becker (1929) records the absence of a definite anteclypeus in *Naucoris cimicoides.* There is no indication of any separation of the clypeal area into postclypeus and anteclypeus in these forms, and, furthermore, there are no anteclypeal invaginations supporting the hypopharynx. Heads that have been treated with caustic potash show the pharyngeal structures through the surface, and at first glance these appear to be the anteclypeus. The pharyngeal structures in these forms are developed entirely from the hypopharynx. They consist of the pharyngeal pump and two long wings, one extending from each corner of the hypopharynx dorsad into the head cavity, reaching the occipital border of the head.

The paraclypeal areas are always well developed in the Heteroptera. They extend along each side of the anteclypeus and are bounded laterally by the genal suture. They have been termed the jugae by students of this suborder and have occasionally been referred to as the lorae. They are homologous with the paraclypeal areas of the Homoptera. Their extent varies greatly. They are smallest in *Pelocoris femoratus* (Fig. 220, *pac*) and in *Notonecta* sp. (Fig. 222). Their limits in these forms can be determined only by a study of the internal structure. *Brochymena* sp. (Figs. 208 and 209), *Stethaulax marmoratus* (Fig. 210), *Corimelaena* sp. (Fig. 211) and *Cyrtomenus mirabilis* (Fig. 212) show the greatest development of the paraclypeal areas. They are equal to or exceed the length of the anteclypeus and crowd the maxillary plates to the lateral or ventral aspect of the head. They are also comparatively long in *Corythuca ciliata* (Fig. 199) and *Phymata* sp. (Figs. 202 and 203). Intermediate lengths between these and *Triphleps insidiosa* (Fig. 158) may be observed in such forms as *Nabis subcoleoptratus* (Figs. 166 and 167), *Corizus* sp. (Figs. 188 and 189), and *Neides muticus* (Figs. 186 and 187).

The Maxillary Plates.—These structures in the Heteroptera are entirely homologous with those of the Homoptera. They are separated from the paraclypeal areas by the genal sutures and lie alongside of the anterior half of the anteclypeus in such forms as *Belostoma flumineum* (Figs. 116 and 117), *Ranatra americana* (Figs. 121 and 122), *Hydrometra martini* (Fig. 145), *Nabis subcoleoptratus* (Fig. 166), and many other forms. Due to the elongation of the paraclypeal areas, the maxillary plates are entirely lateral and ventral in *Phymata* sp. (Figs. 272 and 273), *Brochymena* sp. (Figs. 275 and 276), *Corimelaena* sp. (Fig. 278), *Stethaulax marmoratus* (Fig. 279), and *Cyrtomoenus mirabilis* (Fig. 280).

The maxillary plates are fused with the gena and postgena without trace of sutures. They form most of the lateral and ventral aspects of the head. The maxillary and labial sutures described in the Homoptera (Muir, 1926) are not present in the Heteroptera. It is stated by Muir and Kershaw (1911b) that the basal joint of the labium frequently fuses with the maxillary plates and becomes a part of the head capsule. The author has found no morphological evidence of this in either nymphs or adults.

The Bucculae.—The ventral margins of the maxillary plates are bent at an angle, in many species, forming a pair of projections which have been termed the bucculae (*bu*). They serve as a support to the labium when it is functioning and a protection to it when it is at rest. These structures are modifications of the maxillary plates in the opinion of most workers (MacGillivray, 1923b). Bugnion and Popoff (1911) state that Heymons considers them to represent the rudiments of the

maxillary palps. Many species of the Heteroptera lack these structures and they occur in varying degrees of development in the other species. They are lacking in *Cimex lectularius* (Figs. 235 and 237), *Gelastocoris* sp. (Figs. 234 and 236), and *Systelloderus biceps* (Figs. 248 and 249). Rudimentary bucculae may be seen in *Triphleps insidiosus* (Fig. 240) and *Alydus* sp. (Figs. 263 and 264). They are well developed in *Lamprocanthia* sp. (Fig. 238), *Neides muticus* (Fig. 261), *Brochymena* sp. (Fig. 277), and *Stethaulax marmoratus* (Fig. 279). *Corythuca ciliata* (Figs. 270 and 271) shows the most extensive development of the bucculae. They are projected forward, in the adult, curve around the front of the labium and almost meet.

An effort was made to use this character to show relationships between the various families but no definite results were obtained. They are well developed in such obviously unrelated families as the Belostomatidae (Fig. 214), Saldidae (Fig. 238), Tingitidae (Fig. 271), and Pentatomidae (Fig. 275). They are absent or rudimentary in many equally unrelated families. The bucculae are perhaps more universally well developed in the higher groups, especially in the Pentatomoidea.

THE LABRUM.—This sclerite is attached to the ventral or cephalic margin of the anteclypeus. The Heteroptera may be divided into three groups on the basis of the form of labrum. The first group consists of those forms having a broad, flap-like labrum, and the second contains those species with a long, narrow, triangular labrum. There are a number of intergrading forms in these two groups, and they can be arranged in a fairly regular series. The labrum of the third group consists of a broad, flap-like sclerite with a long, pointed outgrowth from the epipharyngeal area which projects beyond the distal margin of the labrum. This projection has been termed the epipharynx (Fig. 145, *epi*).

The labrum of the first group has been described as the most primitive type found in the suborder Heteroptera and we find it characteristic of the following families: Cimicidae, *Cimex lectularius* (Figs. 152, 153, and 154), Saldidae, *Lamprocanthia* sp. (Figs. 155 and 156), Anthocoridae, *Triphleps insidiosus* (Figs. 157 and 158), Naucoridae, *Pelocoris femoratus* (Figs. 126 and 127), Notonectidae, *Notonecta* sp. (Figs. 130 and 131), and Corixidae, *Corixa* sp. (Figs. 134 and 135).

The families, Reduviidae, *Sinea* sp. (Fig. 159), *Emesa brevipennis* (Figs. 162 and 163) and *Melanolestes abdominalis* (Fig. 164); and Nabidae, *Nabis subcoleoptratus* (Fig. 167), show intermediate stages between the first and second groups. The labrum is rather broad but, nevertheless, longer than broad. *Systelloderus biceps* (Figs. 168 and 169), *Ceratocombus vagans* (Figs. 170 and 171), and *Miris dolobratus* (Fig. 173) possess labra that are narrow but comparatively short. The labrum reaches its greatest length in such forms as *Belostoma flumineum*

(Fig. 118), *Neides muticus* (Figs. 184 and 185), *Myodochus serripes* (Fig. 183), *Euryophthalmus succinctus* (Fig. 179) and *Harmoestes reflexulus* (Fig. 266).

The third group consisting of those species which possess an epipharyngeal projection, forms a very interesting and distinct unit. A study of *Gerris marginatus* (Fig. 226) and *Naeogeus burmeisteri* (Fig. 229) shows clearly that this projection extends from the under surface of the labrum and hence is purely epipharyngeal in character. It is not always so obvious that it arises from this region alone, as in *Rhagovelia obesa* (Fig. 228), but careful observation proves it to be true in the most obscure cases. This epipharyngeal projection occurs in the following families: Gerridae, *Gerris marginatus* (Fig. 226); Veliidae, *Rhagovelia obesa* (Figs. 141, 142, 227, and 228); Mesoveliidae, *Mesovelia bisignata* (Figs. 143 and 230); Naeogeidae, *Naeogeus burmeisteri* (Figs. 146 and 229); Ochteridae, *Ochterus americanus* (Fig. 149); and Nerthridae, *Gelastocoris* sp. (Fig. 148). The process is very small in the last two families.

The question arises as to whether or not the greatly elongated labrum of the second group is a combination of the labrum and epipharynx of this third group. The ectal surface of the epipharynx might have become sclerotized and joined to the labrum without trace of a suture. That such an occurrence would be possible is suggested in *Myodochus serripes* (Fig. 183), *Alydus* sp. (Fig. 192), and *Leptocoris trivittatus* (Fig. 193). The base of the labrum in these forms is distinctly more sclerotized than the tip and a distinct line of differentiation is observed which has been represented in the figures by dotted lines. This line does not indicate a suture. Is the basal portion labrum and the distal part the epipharynx? The writer prefers to leave the query unanswered until further evidence is at hand. There is no other indication of such an occurrence in other members of the group.

The labrum furnishes us with evidence for one very distinct group of families in the Heteroptera and with a fairly good series showing progressive development of the labrum which may prove of value in determining relationships among the remaining families.

THE CAUDAL AND VENTRAL ASPECTS OF THE HEAD.—The caudal or ventral margins of the maxillary plates are united with each other without trace of a suture, forming a continuous sclerotized plate (*gu*) ventrad or cephalad of the occipital foramen (*of*). This union of the maxillary plates with the accompanying sclerotization forms the outstanding difference between the suborders Heteroptera and Homoptera. This area has been termed the gular area, although a true gula does not occur in this order. MacGillivray (1923) calls the region the genaponta but the author retains the older term for it.

The labium is attached to the cephalo-ventral margin of this plate which, in many species, is notched to receive it: *Triphleps insidiosus* (Fig. 309) and *Ochterus americanus* (Fig. 303). The labrum closes the cephalic side of this notch, as shown in *Ranatra americana* (Fig. 284), *Pelocoris femoratus* (Fig. 288), and *Alydus* sp. (Fig. 330). The labium is attached caudad of the cephalic margin in such forms as *Brochymena* sp. (Fig. 341) and *Stethaulax marmoratus* (Fig. 344). There is a large opening apparent in the head capsule in these forms when the labium is removed. This was described by MacGillivray (1923b) as an artifact which he termed the labiafossa (Figs. 340, 341, and 342, *lf*). A sclerotized bridge extends across the cephalic margin of the labiafossa in some species, *Brochymena* sp. (Figs. 341 and 342, *gy*). This structure was termed the gymnoid by MacGillivray (1923b).

Large projections extend into the head cavity from the margin surrounding the occipital foramen in many species. These structures are termed the occipitalia (*oc*) by MacGillivray (1923b). They are essentially apodemes and may be seen in *Sinea* sp. (Fig. 311), *Melanolestes abdominalis* (Fig. 315), *Phymata* sp. (Fig. 338), and *Pelocoris femoratus* (Fig. 287). They are extremely long, extending through the prothorax in *Belostoma flumineum* (Fig. 282), *Ranatra americanus* (Fig. 283), and *Gerris marginatus* (Fig. 293). The figures do not show the entire length of these structures. Two pairs of occipitalia are found in *Pelocoris femoratus* (Fig. 288). The function of these structures is to serve as places of attachment for muscles. The muscles which move the head are attached here as well as the protractor and retractor muscles of the maxillary stylets.

The caudal or ventral aspects of the head in various Heteroptera are shown in the plates (Figs. 281-345). Comparatively few characters of importance in the study of relationships are found in this aspect. The complete lack of sutures renders it impossible to delimit the various areas of which it is composed.

The Tentorium.—There is no trace of a tentorium in the Heteroptera. MacGillivray (1923b) states that only the caudal two-thirds of the metatentoria are to be found in *Benacus*. The metatentorinae are wanting, and the remains of the metatentoria are, therefore, far removed from the usual point of invagination, and there is no evidence that any invagination has occurred. Ekblom (1926), Becker (1929), and Hamilton (1931) all describe a tentorium consisting of the body of the tentorium, the anterior arms, and the posterior arms. The structures which they have called the anterior and posterior arms of the tentorium are the hypopharyngeal evaginations similar to those described in the Homoptera. These evaginations project into the head capsule and form places for the attachment of the pharyngeal muscles and guides or supports for the

maxillary stylets. The fusion of these posterior evaginations with the metatentoria was also described in the Homoptera. Hence, the two-thirds of the metatentoria described by MacGillivray are really these hypopharyngeal structures and the metatentoria are entirely wanting. The corpotentorium of the authors mentioned above is apparently the floor of the hypopharynx, as seen in the figures given by Becker (1929).

The structures here described are all present in the Homoptera in addition to a rather typical tentorium. Therefore the structures in the Heteroptera must be homologous with the hypopharyngeal structures of the Homoptera and not with the tentorium. There is no evidence of any part of the tentorium in the Heteroptera.

A peculiar structure is found in the Saldidae. A large, deep apodemina is found along each epicranial arm of the nymph of *Lamprocanthia* sp. (Fig. 155, *ap*). These produce long, slender, heavily sclerotized apodemes in the adult which extend into the head cavity (Fig. 308). At first sight one is apt to homologize them with the pretentoria. They suggest the condition found in the Cicadellidae and described in the section on the tentorium of the Homoptera. They are not invaginated at the same point, however, in the two groups. Those in the Cicadellidae arise in the genal sutures, while in the Saldidae, they occur in the epicranial arms. They are not, therefore, homologous with the pretentoria but are secondary structures with no counterpart in other Heteroptera.

THE LABIUM.—The labium of the Heteroptera was formerly considered to vary in the number of segments it contained, having either three or four segments, and this fact was used in the classification of the group. Recent studies have led to the conclusion that all Heteroptera possess a four-segmented labium. All or part of the basal segment may become attached to the head capsule according to Muir and Kershaw (1911b). This conclusion was based upon embryological evidence, and further evidence must come from this source before we can hope to clarify the situation. We may still use the occurrence of three or four visible segments in the labium to help us in our classification, but we can no longer consider it to be of great phylogenetic importance. No morphological evidence of this fusion was found.

The writer did not include the labium in the present study. It shows some very interesting modifications and would repay extensive study. A few figures have been included in the plates to illustrate some of these variations (Figs. 392-398).

The direction of the mouth opening as evidenced by the place of attachment of the labium is of some interest. Attempts have been made to use this character in the classification of the suborder. These attempts will be discussed later in this paper. The mouth opening is most nearly cephalad in such forms as *Triphleps insidiosus* (Figs. 239 and 240),

Melanolestes abdominalis (Fig. 245), and *Systelloderus biceps* (Figs. 248 and 249). The direction swings considerably ventrad in *Emesa brevipennis* (Figs. 243 and 244), *Nabis subcoleoptratus* (Figs. 246 and 247), and *Sinea* sp. (Figs. 241 and 242). It is definitely ventral in *Neides muticus* (Figs. 260 and 261), *Alydus* sp. (Figs. 263 and 264), and *Piesma cinerea* (Fig. 269). The opening occurs on the ventral surface caudad of the cephalic margin, as shown by the position of the labiafossa in *Phymata* sp. (Figs. 337 and 338), *Brochymena* sp. (Figs. 341 and 342), and *Stethaulax marmoratus* (Fig. 344).

The Mandibular Levers.—The levers which attach the mandibular stylets to the head capsule and which increase the action of the extensor and retractor muscles of the stylets have been described in the Notonectidae by Geise (1883) and in *Nepa* and *Naucoris* by Heymons (1899). The author described them in the Aradidae (Spooner, 1920). It remained for Ekblom (1929) to make an extensive study of these levers and to make use of them in attempting to show the relationships between the families of the Heteroptera. He described four main types of these levers.

The first type has a triangular lever attached to the membrane surrounding the base of the mandibular stylets. The second form is a three-branched lever, one end of which is attached directly to the stylet. The third is a triangular form, attached directly to the stylet which is folded anteriorly, and has a double attachment to the head capsule. The fourth type consists of a quadrangular lever with double walls, closely attached to the base of the mandible but not firmly united with it. The protractor muscle is attached to the center of this type. He uses these four types of mandibular levers as the basis for dividing the Heteroptera into four groups. These groups will be discussed in a later section of this paper.

The writer has studied the mandibular levers of all of the families of the Heteroptera in which material was available and has found them to be of considerable interest. Two of the types described by Ekblom were found to form rather clear-cut groups. These were his third and fourth types. The first and second groups were not easily separated in all cases, and evidence of at least two more types was found.

Type one, the triangular lever attached to the membrane surrounding the base of the mandibular stylet, is found in by far the larger number of the Heteroptera. The large amount of variation within the group may be seen by comparing the figures (369-391). Several other species were examined and the levers were found to come within the range of variation shown in the figures. A tendon of varying length attaches the lever to the membrane about the base of the stylet.

The second type includes, according to Ekblom (1929), *Ranatra* (Fig. 356), *Pelocoris* (Fig. 358), and *Notonecta* (Fig. 359). *Belostoma* (Figs.

354 and 355) should also be included in this group. The great amount of variation is readily observed. A comparison with the lever of *Melanolestes* (Fig. 357) shows that the most consistent difference from the first group lies in the attachment to the mandibular stylets. It is attached directly to the base of the stylets in this second group, while in the first it is attached to the enclosing membrane. Levers of both nymph and adult of *Belostoma* (Figs. 354 and 355) were examined to determine the amount of difference between them. The same thing was done in the aradid, *Aneurus* sp. (Figs. 386 and 387). No essential change occurs between these stages of the insect.

Pelocoris (Fig. 358) and *Notonecta* (Fig. 359) have levers which are sufficiently different to warrant further discussion. The lever of *Pelocoris* is a long, slender loop with one end attached to the head capsule and the other end to the mandibular stylet. The protractor muscle is fastened to the elbow of the loop and a contraction of the muscle brings the ends of the loop toward each other and thus forces the stylet forward. This arrangement is entirely different from that found in any other species. Two pieces make up the lever of *Notonecta* (Fig. 359), a larger triangular piece attached to the head capsule, and a smaller piece attached at an angle just before the apex of the first. The condition of the specimens at hand made it impossible to determine just where the muscles are attached. This is another unique form of lever. The second of Ekblom's groups, then, appears to contain at least three types of levers.

The third group described by Ekblom is found only in the Corixidae, *Corixa* sp. (Fig. 349). This form is triangular and is folded at the outer margin with a rod-like extension extending to the mandible and uniting directly with it.

The fourth type, as was stated, forms a fairly well isolated group. The quadrangular shape of the lever with the rod-like projection fastening to one face and extending directly to the mandibular stylet is found in *Gerris marginatus* (Fig. 360), *Rhagovelia obesa* (Fig. 361), *Mesovelia bisignata* (Fig. 362), *Hydrometra martini* (Fig. 363), and *Naeogeus burmeisteri* (Fig. 364). *Ochterus viridifrons* (Fig. 365) shows a modification of this type in that the rod-like extension is attached to the edge of the plate and that the plate approximates a triangle in form. The lever is attached directly to the mandibular stylet. *Ochterus americanus* (Fig. 366) has the mandibular lever still more triangular in outline, with the arm very slender and tendon-like, while in *Gelastocoris* sp. (Fig. 368) the lever is in the form of a perfect triangle with one corner attached directly to the mandibular stylet.

It is worth calling attention here to the fact that, if we include *Ochterus* and *Gelastocoris,* this group includes all of those forms which possess the epipharyngeal process described in the section on the labrum.

Further discussion of these relationships revealed by the study of the mandibular levers will be made in the section on phylogeny.

A number of species and varieties of *Euschistus* were examined to determine the extent of variation within the genus. *Ochterus viridifrons* (Fig. 365) and *Ochterus americanus* (Fig. 366) show a considerable difference in the shape of the lever. Three species and two varieties of *Euschistus* were examined, but they showed only minor variations in the form of these structures (Figs. 390 and 391).

With the turning in of the direction of the mouth opening from cephalad to ventrad there occurs a bending of the mandibular stylets (Figs. 367, 369, 371, 375, and 376). The levers and the mandibular bases work in the same plane as in those with a cephalic mouth opening, the bend in the stylets accommodating the change in the direction of the mouth opening.

The Maxillary Stylets.—The maxillary stylets are not attached to the head capsule by means of levers in any heteropteron examined by the writer. Their point of attachment varies so greatly that they cannot serve as landmarks for the head sclerites, and a serious study of them has not been included in this work. It was observed that in the Gerridae, *Gerris remigus,* the maxillae followed the occipitalia back into the mesothorax. Muscles were attached to the occipitalia and to the body wall of the mesothorax.

PHYLOGENY OF THE HETEROPTERA

The Heteroptera is a much larger and more varied group than the Homoptera and consequently the relationships within this group are much more difficult to determine. The present studies have brought to light some characters which are unquestionably of value in deciphering these relationships, and while much remains to be done they are given here in the form of suggestions which may lead to further discoveries.

This suborder appears to be an offshoot of the early Homoptera. Evidence for this statement is, first, the earlier appearance of the Homoptera as fossils and, second, the similarity of the anteclypeal region of some of the Fulgoridae (*Otiocerus wolfii,* Fig. 346) with that of many heteropterons (*Belostoma flumineum,* Fig. 347 and *Euschistus tristigmus,* Fig. 348). The peculiar modification of the alimentary canal known as the filter chamber, in which the caudal part of the intestine loops forward and becomes imbedded in the walls of the ventriculus, is found in most Homoptera. The fact that it is absent in the Fulgoridae and in all of the Heteroptera (Kershaw, 1913) is further indication of the probable ancestral relationship between these two groups.

Reuter (1910) has given a detailed account of the historical develop-

ment of the classification of the Heteroptera to that date and Ekblom (1929) has brought it up to the present time. A detailed account is not necessary here and only a few of the major contributions will be discussed. Reuter (1884-1891) used the classification of Fieber (1851) in which the Heteroptera was divided into two major groups based on the position of the antennae. These two groups were known as the Cryptocerata and the Gymnocerata. Kirkaldy (1908) discarded these two divisions and proposed two groups based on the method of articulation of the metacoxae which he named the Pagiopoda and the Trachalopoda. He regarded the Pentatomidae as containing those forms, which have retained most of the primitive characters of the Heteroptera, and hence reversed the usually accepted arrangement of the families.

The grouping into the Cryptocerata and the Gymnocerata was abandoned by Reuter (1910) who divided the Heteroptera into six series: Hydrobiotica, Trichotelocera, Anonycha, Onychiophala, Polyneura, and Peltocephala. He based these groups primarily upon the following characters: the presence or absence of ocelli and arolii, the form and structure of the egg, and the condition of the sternal sclerites. His scheme of classification has been largely used since and still forms the basis for most of the present-day work.

Considerable doubt has been expressed recently upon the dependability of the above characters for the separation of the groups. McAtee and Malloch (1924, 1925a, and 1926) point out the modification of the sternal sutures which accompanies the degree of development of the wings. Ekblom (1929) rejects the shape of the egg as a phylogenetic character, and Myers (1924) and Holloway (1935) show that our incomplete knowledge of tarsal structures renders any classification based upon them uncertain.

Ekblom (1929) has given us the most recent scheme of classification of this suborder and his work is by far the most important contribution to the subject in recent times. He bases his classification upon the early scheme of Dufour (1833) and supplies new characters to confirm Dufour's ideas. Dufour divided the Heteroptera into three series, the Geocorises, the Hydrocorises, and the Amphibicorises. Borner (1904) added the Sandaliorrhyncha to include the family Corixidae. These four series are recognized by Ekblom and justified primarily by the types of mandibular levers described in a previous section of this paper.

Evidence obtained in the present study lends support to the validity of this grouping with some minor changes perhaps suggested. The Sandaliorrhyncha, containing the single family Corixidae, is quite evidently valid. The corixids are a very isolated and highly specialized group. The form of the anteclypeus suggests a possible relationship between them and the Saldidae or Cimicidae, but this relationship is extremely remote.

The Hydrocorisae is the least unified group of the four. It contains the families Nepidae, Belostomatidae, Naucoridae, and Notonectidae. As has been pointed out in a previous section of this paper, there are three distinct types of levers in this group, and perhaps the group should be split into three. The Nepidae (Fig. 356) and the Belostomatidae (Fig. 355) would form one group having the three-branched lever described by Ekblom (1929) as typical of the Hydrocorisae. The Naucoridae (Fig. 358) form a group characterized by having the lever in the form of a long, slender loop; while the Notonectidae (Fig. 359) would represent the third group, with a lever consisting of two distinct pieces. The last two families agree in lacking any evidence of the anteclypeus (Figs. 127 and 131).

The third series, the Amphibicorisae, forms a very well defined group. It contains the families Ochteridae, Nerthridae, Naeogeidae, Hydrometridae, Mesoveliidae, Veliidae, and Gerridae. These forms all possess the epipharyngeal projection from the labrum (Figs. 221 and 226-231), and the mandibular levers (Figs. 360-366) agree in being attached directly to the mandibular stylets. Most of the levers are quadrangular in form, with the Ochteridae showing a gradual shift to the triangular type characteristic of the Geocorisae (Figs. 365 and 366). The Ochteridae and the Nerthridae, on the other hand, agree with the Naucoridae and the Notonectidae in lacking any evidence of the anteclypeus, and thereby bridge the gap between the Amphibicorisae and the Hydrocorisae.

The remaining families of the Heteroptera are included in the series Geocorisae. This forms a very large group, all of the members of which possess a more or less triangular mandibular lever attached to the membrane surrounding the base of the stylet rather than directly to the stylet. The dead structures give very little aid in subdividing this group or in suggesting relationships between the families.

The danger of misinterpreting modifications accompanying similarity of habits is encountered in a group so large as this. A very interesting case of this has been described by China (1931). He states that the coiling of the stylets characteristic of the Aradidae (Figs. 386 and 387) is also found in the European family Termitaphididae and that they are partially coiled in the Plataspidae, another old world family. *Bozius* also has a similar structure. These four otherwise unrelated groups with similar long coiled stylets all have the habit of feeding on fungus.

The predacious forms in the North American families seem to agree in certain characteristics, such as the comparatively wide labrum, the cephalic direction of the mouth opening and in the lack of bucculae. There are, however, many exceptions to these generalities and this may also be a case of morphological parallelism.

The families Cimicidae (Fig. 152), Anthocoridae (Fig. 157), and Saldidae (Fig. 156) form a group characterized by a very wide, flap-like

labrum. The bucculae, on the other hand, are well developed in the Saldidae, rudimentary in the Anthocoridae, and wanting in the Cimicidae. The Reduviidae (Figs. 161, 163, and 165), the Nabidae (Fig. 167), and the Enicocephalidae (Fig. 168) show intermediate stages in regard to the width of the labrum. The Cryptostemmatidae (Fig. 170) and the Miridae (Fig. 173) seem to be related followed, perhaps, by the Lygaeidae (Fig. 176), Pyrrhocoridae (Fig. 180), Corizidae (Fig. 189), and Alydidae (Fig. 192). The last three families show progressive stages in the elongation of the paraclypeal areas and the accompanying lateral or ventral position of the maxillary plates. This is characteristic of the Pentatomoidea, including the families Pentatomidae (Fig. 208), Cydnidae (Fig. 212), and the Corimelaenidae (Fig. 211).

The Aradidae (Fig. 207), the Phymatidae (Fig. 203), the Piesmidae (Fig. 196), and the Tingitidae (Fig. 109) seem to stand rather alone with the great development of the bucculae in common. The Piesmidae (Fig. 196) shows an enormous elongation of the paraclypeal areas. The Neididae (Fig. 185) also possess well developed bucculae but otherwise agree with the Lygaeidae (Fig. 176).

The head structures, on the whole, give comparatively little help in subdividing the Geocorisae. Studies of other structures will be necessary to determine the actual relationships in this group. Some such studies have been made and a brief review of them will be of value.

Taylor (1918) studied the thoracic sclerites and divided the Heteroptera into five groups on the basis of thoracic and coxal characters. Four of these groups he states as being similar in general characteristics. Notonectidae, Corixidae, Belostomatidae, and Nepidae form the first and most distinctive group, all with large metathoracic coxae overlapped by the epipleura and having the meso- and metathoracic pleurae distorted. This group corresponds somewhat with the Sandaliorrhyncha and the Hydrocorisae. The second group includes the Miridae, Nabidae, and Cimicidae which have exposed meso- and metathoracic coxae. The Reduviidae and the Phymatidae form the third group, characterized by the presence of a true coxal cleft in the metathorax. The fourth group, with the mesothoracic scutellum prolonged over the abdomen, includes the Coreidae, Lygaeidae, Tingitidae, Pentatomidae, Scutellaeridae, and Corimelaenidae. The Neididae, Gerridae, and Emesidae form the fifth group, all having the mesothoracic pleurae lengthened horizontally. The last four groups do not agree with the findings in the study of the head structures.

Tullgren (1918) made a very interesting study of the occurrence of Trichobothria in the Heteroptera. These are described by the author as auditory hairs and are apparently the tactile sense organs described by Snodgrass (1935). They have been extensively used in the classification of the spiders. Tullgren found them present in eight families. The

Thyreocoridae, Scutellaeridae, and Pentatomidae had them arranged in the same pattern on the same sternites. The Coreidae, Neididae, and Piesmidae each possessed them and each family had a characteristic arrangement of them. The Pyrrhocoridae and the Lygaeidae agreed in having them arranged in the same pattern but differing from those mentioned above. He found no evidence of these structures in the other families of the Heteroptera nor in the Homoptera.

The genitalia in the Hemiptera were studied by Pruthi (1925). He recognized two main types of genitalia in the Heteroptera which he designated as the pentatomid type and the reduviid type. The pentatomid type included the families Saldidae, Aradidae, Pentatomidae, Coreidae, Neididae, and Lygaeidae. All of the remaining families were included in the group having the reduviid type of genitalia.

The metasternal scent glands were studied by Brindley (1930). He found them present in most of the families. They were absent in the Nepidae and the Hydrometridae. Unfortunately he apparently did not investigate the Naeogeidae, Ochteridae, Nerthridae, Anthocoridae, Veliidae, or Mesoveliidae.

China (1933) bases his classification partially on habits and points out a series originating in the rapidly running and flying, littoral Saldidae and Ochteridae through the more sluggish Nerthridae to the typical aquatic forms Nepidae and Belostomatidae. He points out the structural characters accompanying these changes in habit. He does not give detailed reasons for the remainder of his classification.

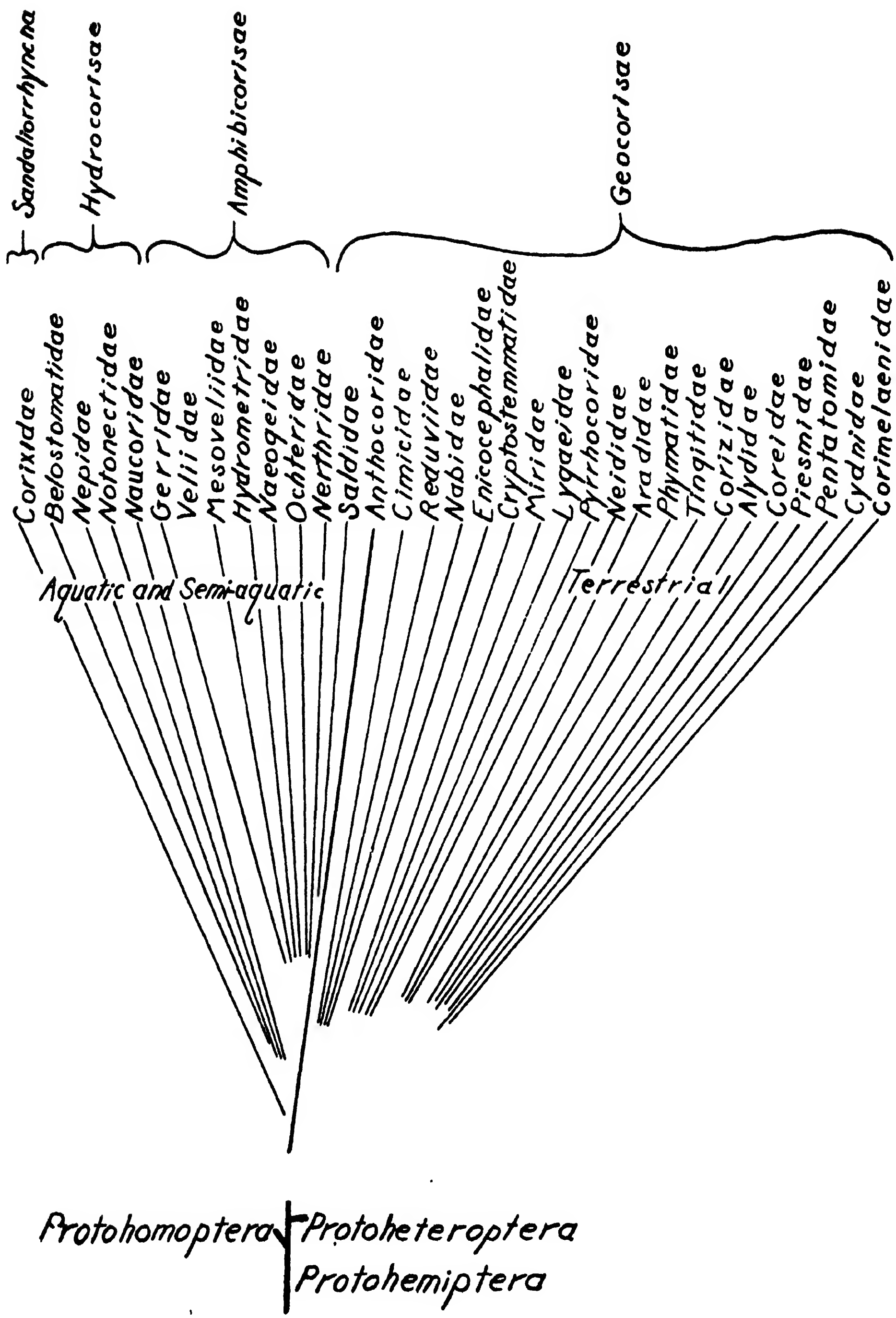
This brief review of the important works on the comparative morphology of the Heteroptera indicates that further studies are badly needed, particularly detailed comparative studies of the various parts of the body. Until these are made we cannot hope to arrange the Geocorisae in any satisfactory phylogenetic series.

The accompanying diagram (Text-figure 2) gives a graphic idea of the relationships of the Heteroptera suggested by the study of the head capsule.

SUMMARY

A comparative study of the head capsule of the adults and nymphs of all of the North American families of the Hemiptera in which material was available has been made. This included all of the families of the suborder Homoptera excepting the Coccidae and all of the Heteroptera excepting the families Thaumasticoridae, Microphysidae, and Termatophylidae. Nymphs were available in all of the families studied except the Piesmidae and the Hydrometridae.

Evidence has been advanced to show that the Homoptera represent



TEXT-FIGURE 2

the more primitive suborder and that some members of the Fulgoridae have retained some of the most primitive characteristics found in the group. A series of forms was described showing the gradual development of the paraclypeal areas from the postclypeus by the extension of the so-called frontal sutures. The homologies of these areas have given rise to more discussion than any other part of the hemipterous head.

The structure of the head, particularly of the tentorium, suggests that the other families of the Homoptera have developed from the primitive Cercopidae. The two subfamilies of the Cercopidae differ considerably in head structure. The Cercopinae, characterized by a greatly reduced frons gives rise to the Tettigonidae, Membracidae, Cicadidae, Psyllidae, and Aphididae; while the Aphrophorinae, members of which have retained the large frons characteristic of the Fulgoridae, leads to the Cicadellidae, Aleyrodidae, and Coccidae. The Tettigonidae has alternately been considered as a subfamily of the Cicadellidae and as a separate family. This study indicates that it is a distinct family considerably removed from the Cicadellidae.

Facts are presented to show that the parts of the heteropterous head are homologous with those of the Homoptera, a fact which has often been denied. This removes the objection formerly advanced, against deriving the Heteroptera from the Homoptera.

The Heteroptera were found to lack any trace of a true tentorium. The structures usually described as such originate from the hypopharynx. These hypopharyngeal structures are also found in the Homoptera in addition to a nearly typical tentorium.

The Heteroptera are best grouped into the four series Sandaliorrhyncha, Hydrocorisae, Amphibicorisae, and Geocorisae. The Anthocoridae or Cimicidae are probably the most primitive forms of the Heteroptera and belong to the Geocorisae. The form of the labrum, the type of mandibular lever, the direction of the mouth opening and the development of the bucculae are the most important structures of the head as far as showing the relationships between the families is concerned. The Sandaliorrhyncha is a small and unique series, rather completely isolated from the rest of the Heteroptera. The second series, the Hydrocorisae, is not clearly limited. Three types of mandibular levers are found in these forms which perhaps justifies their separation into three groups. The Amphibicorisae forms a very well defined group characterized by a single type of mandibular lever and also by the development of an epipharyngeal appendage from the labrum. The mandibular lever in the family Ochteridae, of this group, shows a modification in shape toward that found in the most primitive of the Geocorisae, which perhaps indicates the origin of the Amphibicorisae from that group.

Four families, two in the Hydrocorisae, Notonectidae, and Naucoridae,

and two from the Amphibicorisae, Ochteridae, and Nerthridae, agree in lacking all evidence, both external and internal, of an anteclypeal area. This may bridge the gap between these two series.

The Geocorisae is a large and complex series, the relationships of which remain rather obscure. Detailed comparative studies of other body parts are needed to enable us to understand this group. The form of the labrum presents a series of the Cimicidae, Anthocoridae, Saldidae, Reduviidae, Nabidae, Enicocephalidae, and Miridae, in the order named. The Cryptostemmatidae, Miridae, Lygaeidae, Pyrrhocoridae, and Neididae seem to show intermediate stages in several of the head characters. The Aradidae, Phymatidae, and Tingitidae stand more or less isolated, while the Corizidae, Alydidae, Coreidae, Piesmidae, Pentatomidae, Cydnidae, and Corimelaenidae show progressive enlargement of the paraclypeal areas and an accompanying ventral position of the maxillary plates.

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ABBREVIATIONS USED IN THE PLATES

ac	anteclypeus
af	antafossa
ant	antenna
ap	apodeme
as	antennal shelf or tubercle
at	attachment of mandibular lever to head capsule
bu	buccula
cl	clypeus
ct	corpotentorium
ea	epicranial arm
epi	epipharynx
es	epicranial stem
fr	frons
g	gena
gu	gula or gular area
gy	gymnoid
l	mandibular lever
lb	labium
lbr	labrum
lf	labiafossa
m	mandible
mp	maxillary plate
ms	maxillary suture
mt	metatentorium
o	ocellus
oc	occipital parademe of occipitalia
of	occipital foramen
pac	paraclypeus
pc	postclypeus
pg	postgena
pm	pharyngeal pump muscles
prm	protractor muscles of mandible
pt	pretentorium
rm	retractor muscles
st	supratentorium
v	vertex

PLATE I

Cephalo-ventral aspect of the head

FIG. 1.—*Otiocerus degeerii*, adult.
FIG. 2.—*Lamenia* sp., adult.
FIG. 3.—*Amaloptera uhleri*, adult.
FIG. 4.—*Cyarda melichari*, adult.
FIG. 5.—*Acanalonia* sp., nymph.
FIG. 6.—*Ormenis pruinosa*, adult.
FIG. 7.—*Pelitropis rotatula*, adult.
FIG. 8.—*Oliarus vicarius*, adult.
FIG. 9.—*Catonia impunctata*, adult.
FIG. 10.—*Cixius pini*, adult.
FIG. 11.—*Epiptera* sp., nymph.
FIG. 12.—*Cyrpoptus reineckei*, adult.
FIG. 13.—*Pentagramma vittatifrons*, nymph.
FIG. 14.—*Pentagramma vittatifrons*, adult.
FIG. 15.—*Dictyophora florens*, adult.
FIG. 16.—*Bruchomorpha* sp., adult.
FIG. 17.—*Bruchomorpha* sp., nymph.
FIG. 18.—*Acanalonia latifrons*, adult.
FIG. 19.—*Lepyronia quadrangularis*, nymph.
FIG. 20.—*Lepyronia quadrangularis*, adult.

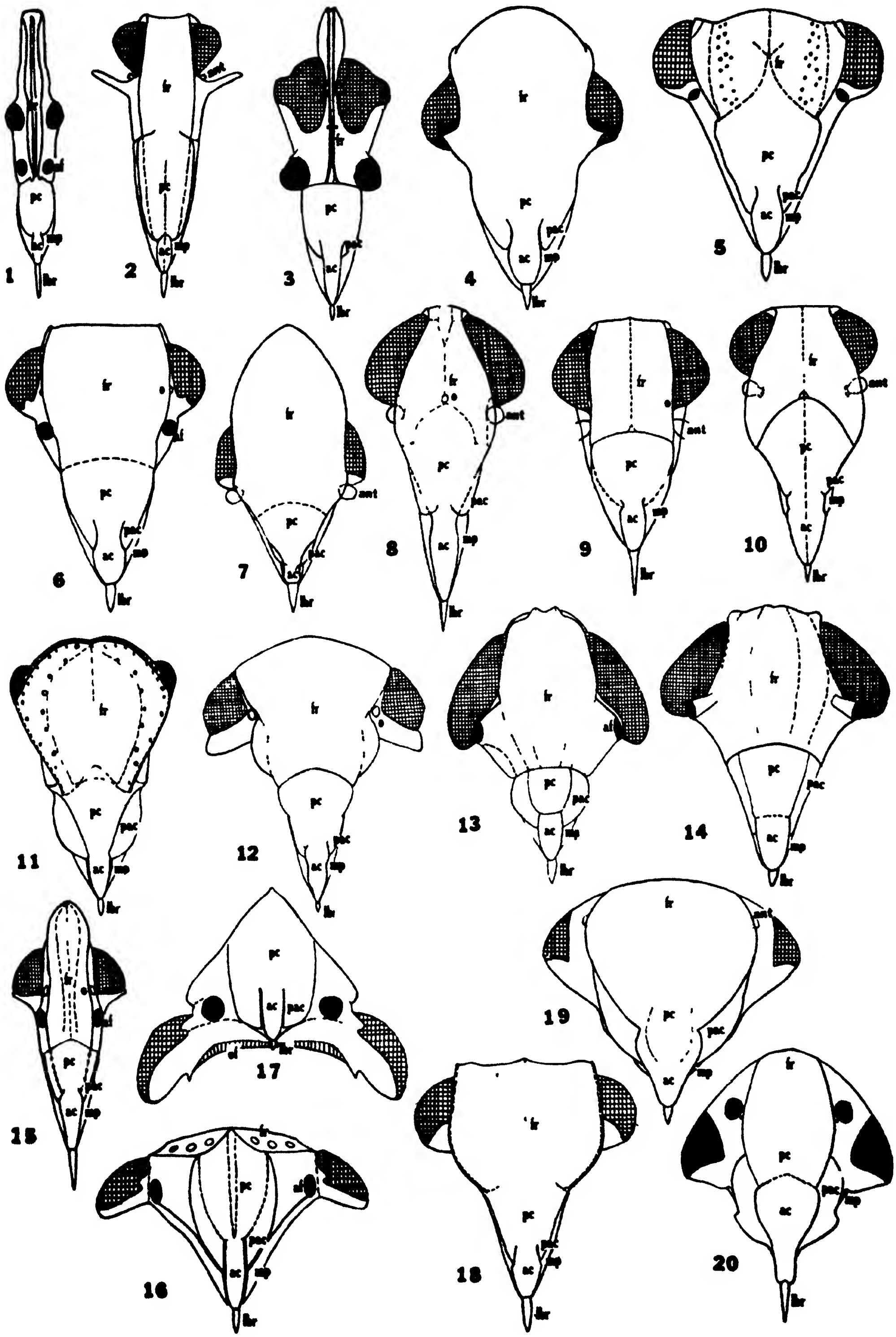
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PLATE I

PLATE II

Cephalo-ventral aspect of the head

Fig. 21.—*Monecophora bicincta,* adult.
Fig. 22.—*Tibicen sayi,* nymph.
Fig. 23.—*Tibicen sayi,* adult.
Fig. 24.—*Ceresa* sp., nymph.
Fig. 25.—*Ceresa* sp., adult.
Fig. 26.—*Carynota mera,* adult.
Fig. 27.—*Agallia constricta,* adult.
Fig. 28.—*Oncometopia undata,* adult.
Fig. 29.—*Jassus olitorius,* nymph.
Fig. 30.—*Jassus olitorius,* adult.
Fig. 31.—*Erythroneura comes,* adult.
Fig. 32.—*Acinopterus acuminatus,* adult.
Fig. 33.—*Lachnus* sp., adult.
Fig. 34.—*Pachypsylla celtidis-mamma,* adult.
Fig. 35.—*Trialeurodes* sp., adult.

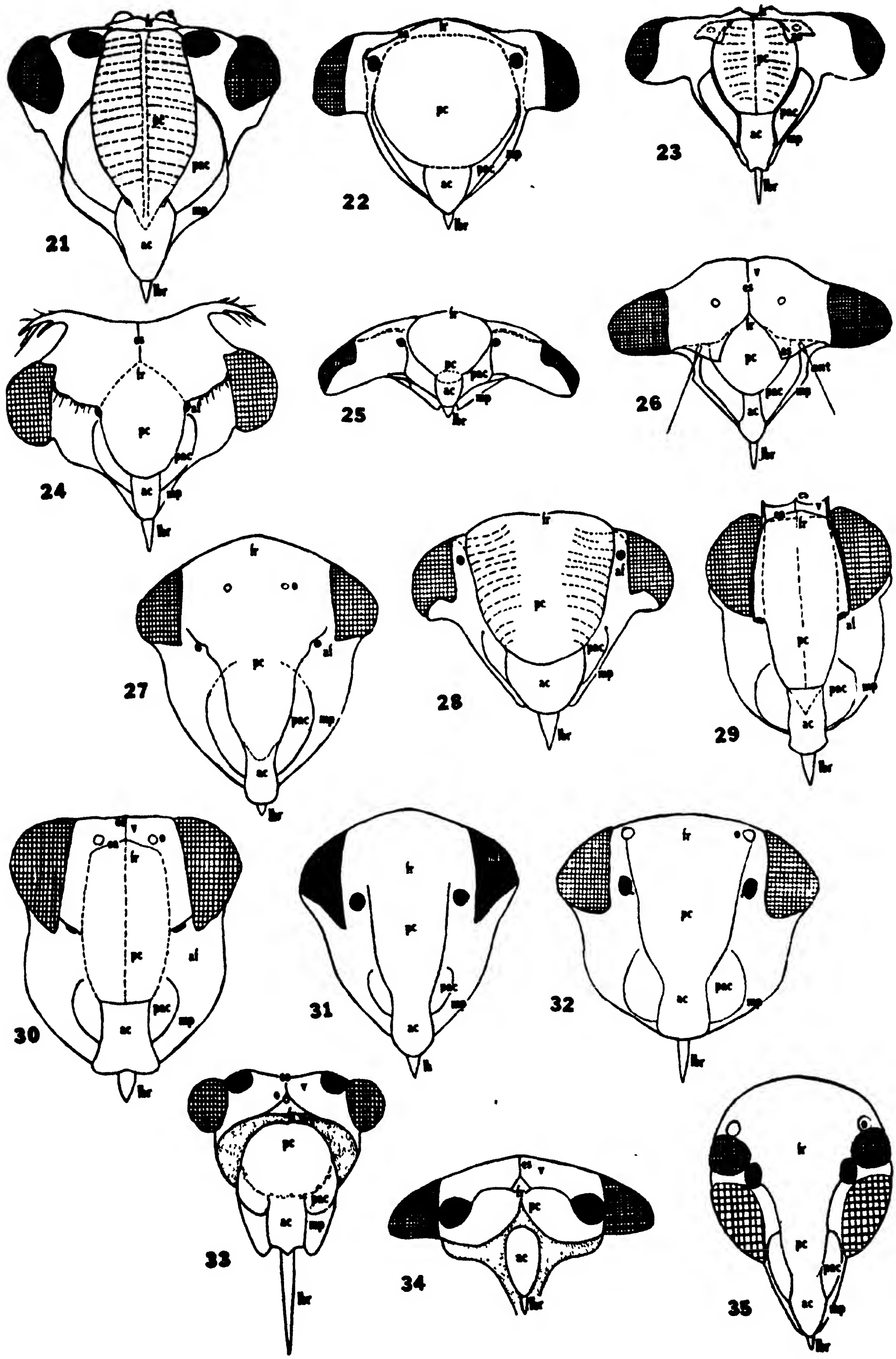

PLATE II

PLATE III

Dorsal aspect of the head

FIG. 36.—*Unknown fulgorid*, nymph.
FIG. 37.—*Acanalonia* sp., nymph.
FIG. 38.—*Liburniella ornata*, nymph.
FIG. 39.—*Pentagramma vittatifrons*, nymph.
FIG. 40.—*Bruchomorpha* sp., nymph.
FIG. 41.—*Bruchomorpha* sp., adult.
FIG. 42.—*Lepyronia quadrangularis*, nymph.
FIG. 43.—*Lepyronia quadrangularis*, adult.
FIG. 44.—*Tibicen sayi*, nymph.
FIG. 45.—*Ceresa* sp., nymph.
FIG. 46.—*Ceresa* sp., adult.
FIG. 47.—*Jassus olitorius*, nymph.
FIG. 48.—*Gypona* sp., nymph.
FIG. 49.—*Oncometopia undata*, adult.
FIG. 50.—*Lachnus* sp., adult.
FIG. 51.—*Pachypsylla celtidis-mamma*, adult.
FIG. 52.—*Trioza tripunctata*, adult.

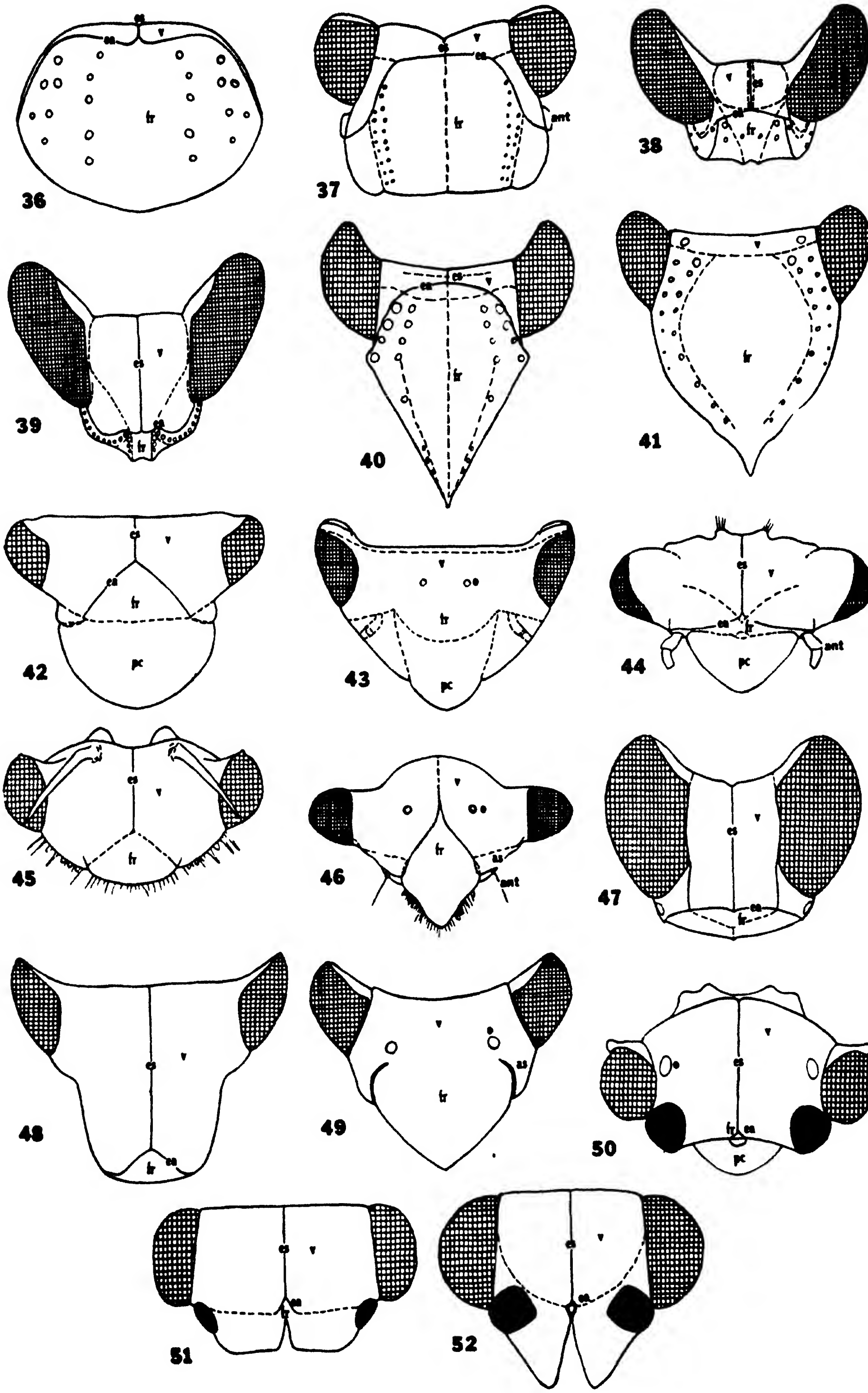

PLATE III

PLATE IV

Lateral aspect of the head

FIG. 53.—*Otiocerus degeerii,* adult.
FIG. 54.—*Lamenia* sp., adult.
FIG. 55.—*Amaloptera uhleri,* adult.
FIG. 56.—*Acanalonia* sp., nymph.
FIG. 57.—*Acanalonia latifrons,* adult.
FIG. 58.—*Ormenis pruinosus,* adult.
FIG. 59.—*Pelitropis rotatula,* adult.
FIG. 60.—*Oliarus vicarius,* adult.
FIG. 61.—*Catonia impunctata,* adult.
FIG. 62.—*Cixius pini,* adult.
FIG. 63.—*Epiptera* sp., nymph.
FIG. 64.—*Cyrpoptus reineckei,* adult.
FIG. 65.—*Pentagramma vittatifrons,* adult.
FIG. 66.—*Dictyophora florens,* adult.
FIG. 67.—*Bruchomorpha* sp., nymph.
FIG. 68.—*Bruchomorpha* sp., adult.
FIG. 69.—*Lepyronia quadrangularis,* nymph.
FIG. 70.—*Lepyronia quadrangularis,* adult.
FIG. 71.—*Monecophora bicincta,* adult.

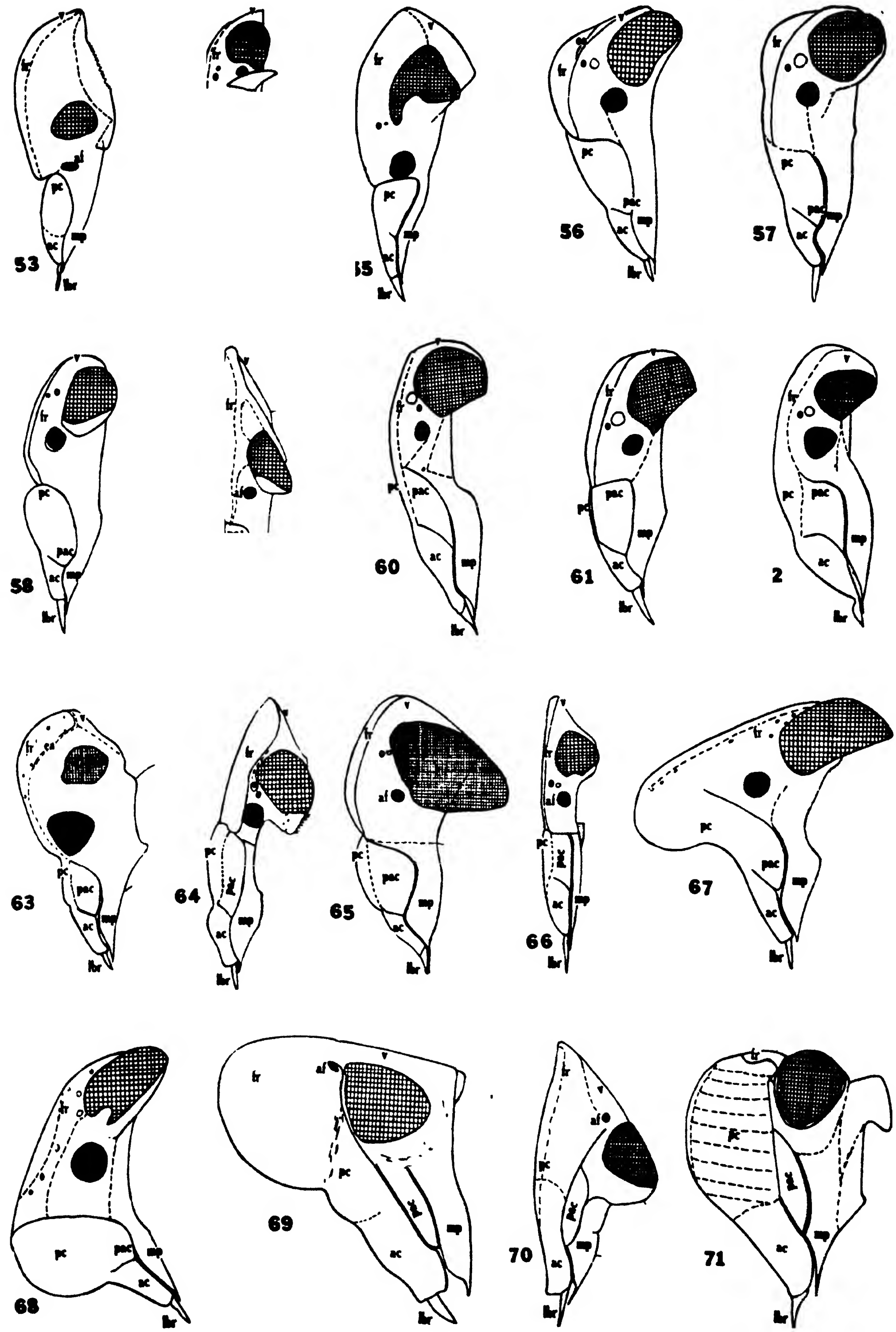
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PLATE IV

PLATE V

Lateral and caudal aspects of the head

FIG. 72.—*Tibicen sayi,* nymph, lateral.
FIG. 73.—*Tibicen sayi,* adult, lateral.
FIG. 74.—*Ceresa* sp., nymph, lateral.
FIG. 75.—*Ceresa* sp., adult, lateral.
FIG. 76.—*Carynota mera,* adult, lateral.
FIG. 77.—*Agallia constricta,* adult, lateral.
FIG. 78.—*Gypona* sp., nymph, lateral.
FIG. 79.—*Oncometopia undata,* adult, lateral.
FIG. 80.—*Phlepsius excultus,* adult, lateral.
FIG. 81.—*Acinopterus acuminatus,* adult, lateral.
FIG. 82.—*Euscelis bicolor,* adult, lateral.
FIG. 83.—*Jassus olitorius,* adult, lateral.
FIG. 84.—*Erythroneura comes,* adult, lateral.
FIG. 85.—*Lachnus* sp., adult, lateral.
FIG. 86.—*Trialeurodes* sp., adult, lateral.
FIG. 87.—*Otiocerus degeerii,* adult, caudal.
FIG. 88.—*Lamenia* sp., adult, caudal.
FIG. 89.—*Acanalonia* sp., nymph, caudal.
FIG. 90.—*Acanalonia latifrons,* adult, caudal.

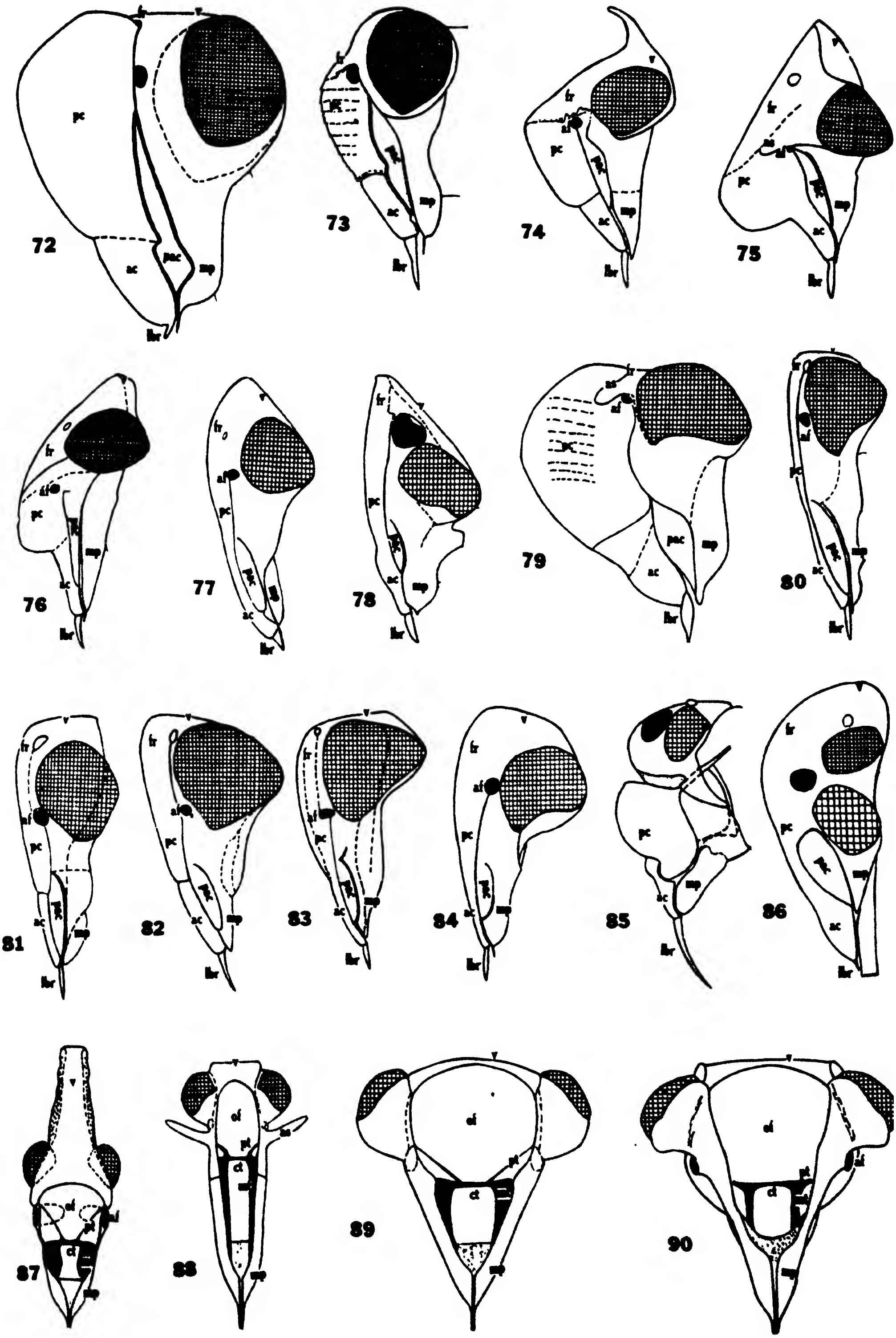

PLATE V

PLATE VI

Caudo-dorsal aspect of the head

FIG. 91.—*Ormenis pruinosa,* adult.
FIG. 92.—*Pelitropis rotatula,* adult.
FIG. 93.—*Oliarus vicarius,* adult.
FIG. 94.—*Catonia impunctata,* adult.
FIG. 95.—*Epiptera* sp., nymph.
FIG. 96.—*Cyrpoptus reineckei,* adult.
FIG. 97.—*Pentagramma vittatifrons,* adult.
FIG. 98.—*Dictyophora florens,* adult.
FIG. 99.—*Bruchomorpha* sp., adult.
FIG. 100.—*Monecophora bicincta,* adult.
FIG. 101.—*Lepyronia quadrangularis,* nymph.
FIG. 102.—*Lepyronia quadrangularis,* adult.
FIG. 103.—*Carynota mera,* adult.
FIG. 104.—*Tibicen sayi,* nymph.
FIG. 105.—*Tibicen sayi,* adult.
FIG. 106.—*Ceresa* sp., adult.
FIG. 107.—*Ceresa* sp., nymph.
FIG. 108.—*Gypona* sp., nymph.

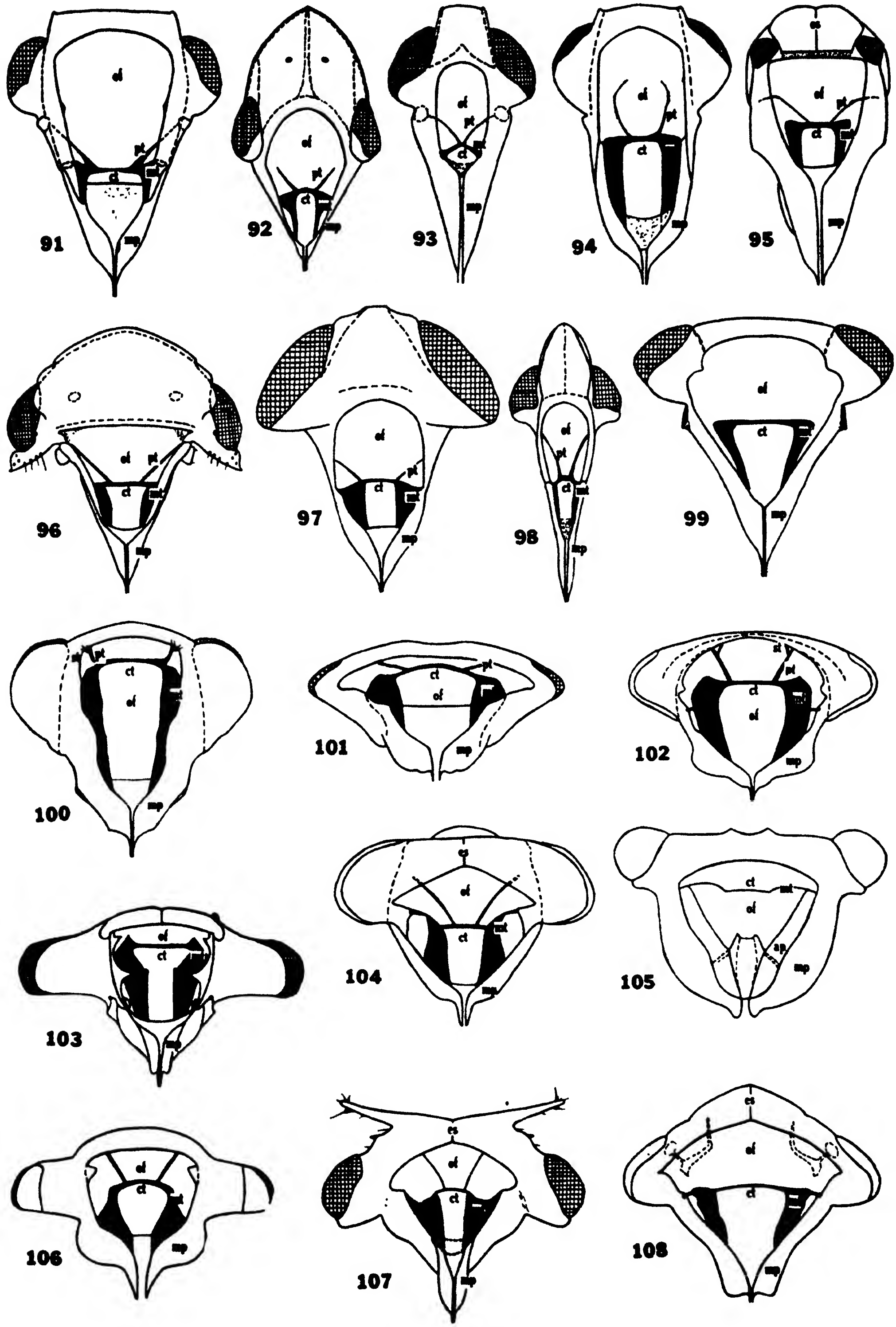

PLATE VI

PLATE VII

Caudo-dorsal, dorsal, and cephalic aspect of the head

FIG. 109.—*Jassus olitorius,* nymph, caudo-dorsal.

FIG. 110.—*Jassus olitorius,* adult, caudo-dorsal.

FIG. 111.—*Acinopterus acuminatus,* adult, caudo-dorsal.

FIG. 112.—*Euscelis bicolor,* adult, caudo-dorsal.

FIG. 113.—*Phlepsius excultus,* adult, caudo-dorsal.

FIG. 114.—*Oncometopia undata,* adult, caudo-dorsal.

FIG. 115.—*Erythroneura comes,* adult, caudo-dorsal.

FIG. 116.—*Belostoma flumineum,* nymph, dorsal.

FIG. 117.—*Belostoma flumineum,* adult, dorsal.

FIG. 118.—*Belostoma flumineum,* adult, cephalic.

FIG. 119.—*Belostoma flumineum,* nymph, cephalic.

FIG. 120.—*Ranatra americana,* adult, cephalic.

FIG. 121.—*Ranatra americana,* adult, dorsal.

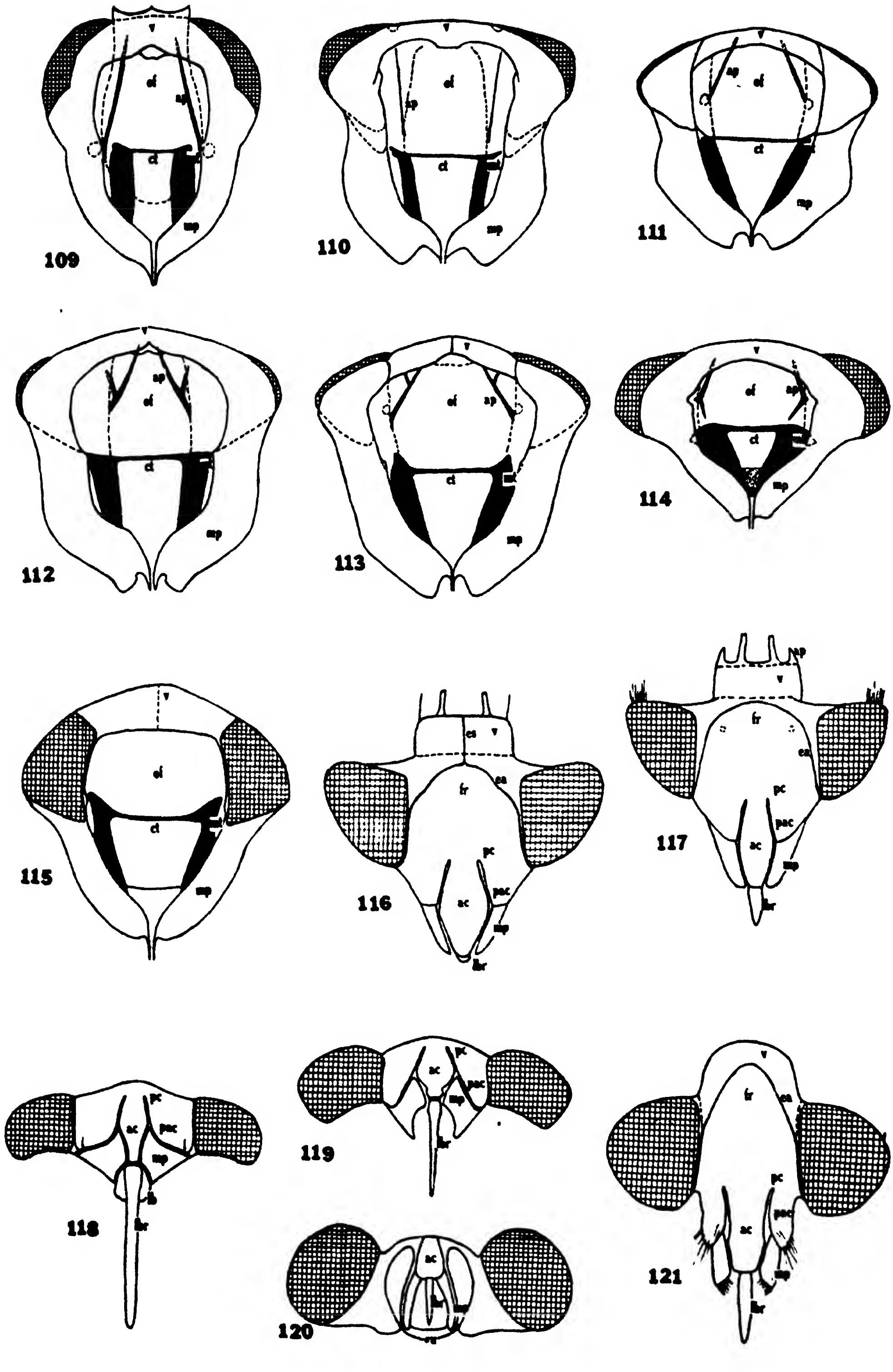

PLATE VII

PLATE VIII

Dorsal, ventral, and cephalic aspects of the head

FIG. 122.—*Ranatra americana,* nymph, dorsal aspect.
FIG. 123.—*Nepa apiculata,* nymph, dorsal aspect.
FIG. 124.—*Nepa apiculata,* adult, dorsal aspect.
FIG. 125.—*Pelocoris femoratus,* nymph, dorsal aspect.
FIG. 126.—*Pelocoris femoratus,* nymph, cephalic aspect.
FIG. 127.—*Pelocoris femoratus,* adult, cephalic aspect.
FIG. 128.—*Pelocoris femoratus,* adult, dorsal aspect.
FIG. 129.—*Notonecta* sp., nymph, dorsal aspect.
FIG. 130.—*Notonecta* sp., nymph, cephalic aspect.
FIG. 131.—*Notonecta* sp., adult, cephalic aspect.
FIG. 132.—*Notonecta* sp., adult, ventral aspect.
FIG. 133.—*Corixa* sp., nymph, dorsal aspect.
FIG. 134.—*Corixa* sp., nymph, cephalic aspect.
FIG. 135.—*Corixa* sp., adult, cephalic aspect.
FIG. 136.—*Gerris marginatus*, nymph, dorsal aspect.

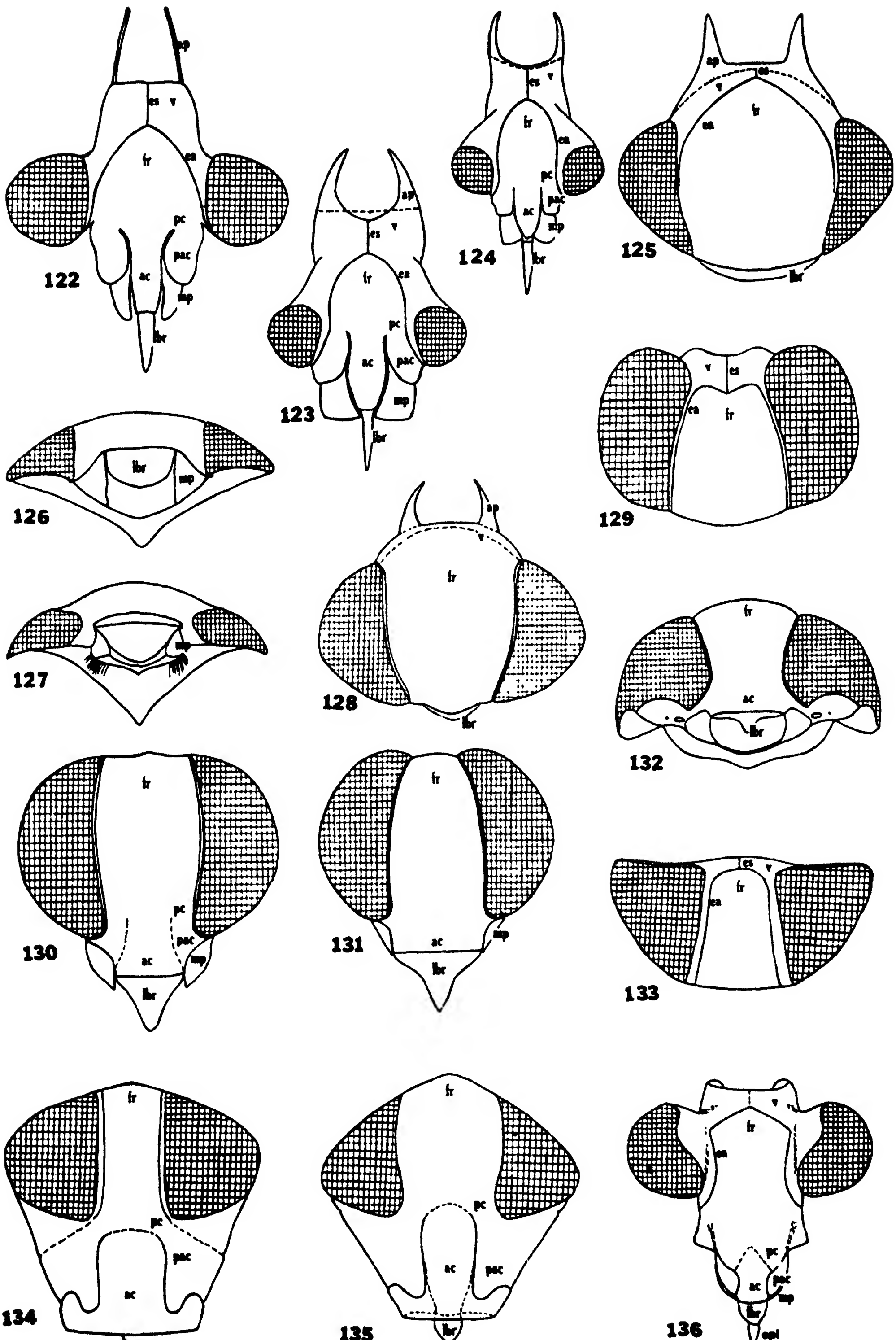

PLATE VIII

PLATE IX

Dorsal and cephalic aspects of the head

FIG. 137.—*Gerris marginatus,* adult, dorsal aspect.
FIG. 138.—*Gerris marginatus,* nymph, cephalic aspect.
FIG. 139.—*Gerris marginatus,* adult, cephalic aspect.
FIG. 140.—*Rhagovelia obesa,* nymph, dorsal aspect.
FIG. 141.—*Rhagovelia obesa,* nymph, cephalic aspect.
FIG. 142.—*Rhagovelia obesa,* adult, cephalic aspect.
FIG. 143.—*Mesovelia bisignata,* adult, dorsal aspect.
FIG. 144.—*Hydrometra martini,* adult, dorsal aspect.
FIG. 145.—*Hydrometra martini,* adult, cephalic aspect.
FIG. 146.—*Naeogeus burmeisteri,* adult, cephalic aspect.
FIG. 147.—*Ochterus americanus,* adult, cephalic aspect.
FIG. 148.—*Gelastocoris* sp., nymph, cephalic aspect.
FIG. 149.—*Ochterus americanus,* nymph, cephalic aspect.
FIG. 150.—*Gelastocoris* sp., adult, cephalic aspect.
FIG. 151.—*Cimex lectularius,* nymph, cephalic aspect.

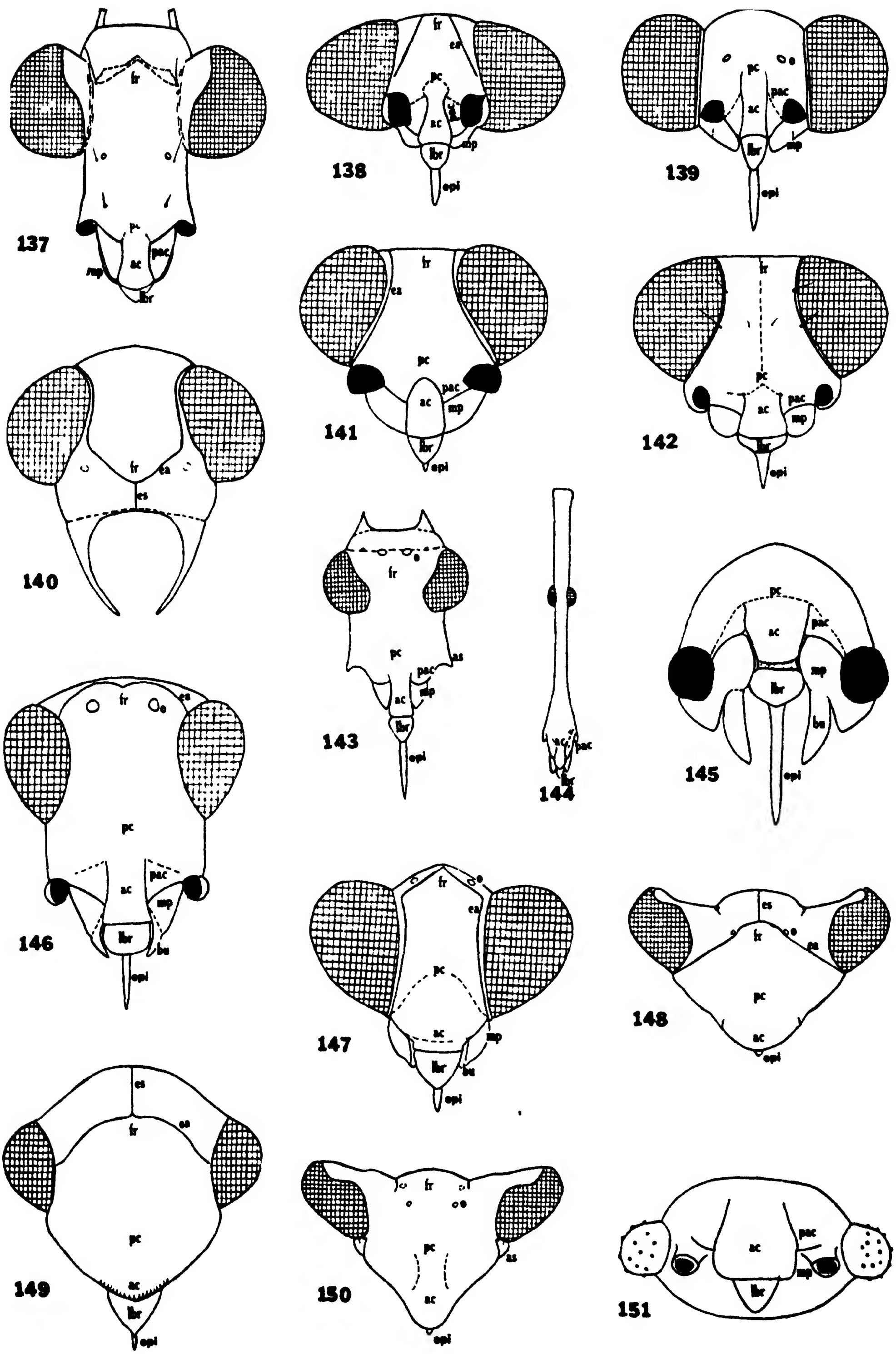

PLATE IX

PLATE X

Dorsal and cephalic aspects of the head

FIG. 152.—*Cimex lectularius*, adult, cephalic aspect.
FIG. 153.—*Cimex lectularius*, nymph, dorsal aspect.
FIG. 154.—*Cimex lectularius*, adult, dorsal aspect.
FIG. 155.—*Lamprocanthia* sp., nymph, cephalic aspect.
FIG. 156.—*Lamprocanthia* sp., adult, cephalic aspect.
FIG. 157.—*Triphleps insidiosa*, nymph, dorsal aspect.
FIG. 158.—*Triphleps insidiosa*, adult, dorsal aspect.
FIG. 159.—*Sinea* sp., nymph, cephalic aspect.
FIG. 160.—*Sinea* sp., nymph, dorsal aspect.
FIG. 161.—*Sinea* sp., adult, dorsal aspect.
FIG. 162.—*Emesa brevipennis*, nymph, dorsal aspect.
FIG. 163.—*Emesa brevipennis*, adult, dorsal aspect.
FIG. 164.—*Melanolestes abdominalis*, adult, dorsal aspect.
FIG. 165.—*Nabis subcoleoptratus*, nymph, dorsal aspect.
FIG. 166.—*Nabis subcoleoptratus*, adult, dorsal aspect.
FIG. 167.—*Nabis subcoleoptratus*, nymph, cephalic aspect.

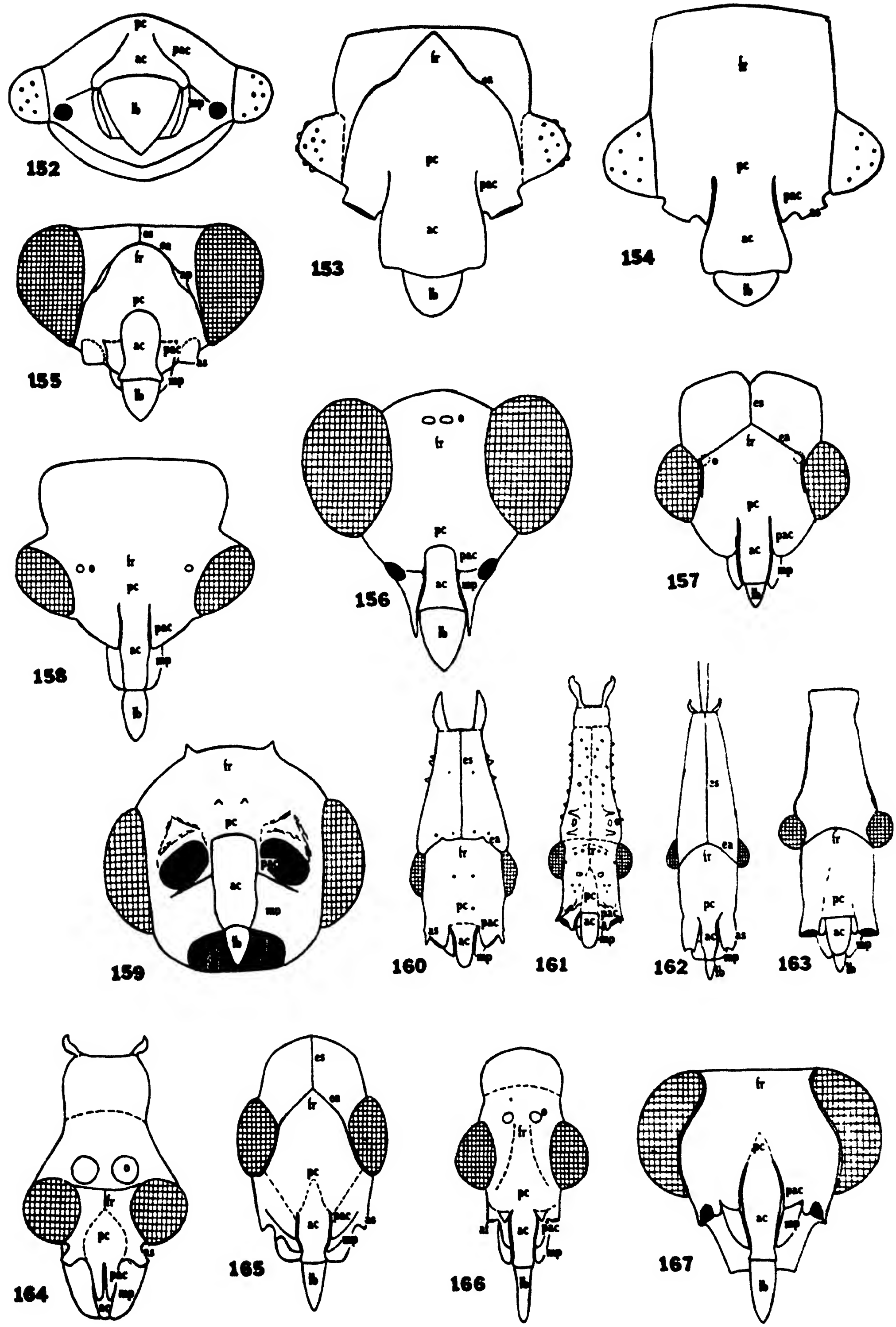

PLATE X

PLATE XI

Dorsal and cephalic aspects of the head

FIG. 168.—*Systelloderus biceps,* nymph, dorsal aspect.
FIG. 169.—*Systelloderus biceps,* adult, dorsal aspect.
FIG. 170.—*Ceratocombus vagans,* nymph, dorsal aspect.
FIG. 171.—*Ceratocombus vagans,* adult, dorsal aspect.
FIG. 172.—*Miris dolobratus,* nymph, dorsal aspect.
FIG. 173.—*Miris dolobratus,* adult, cephalic aspect.
FIG. 174.—*Adelphocoris rapidus,* adult, cephalic aspect.
FIG. 175.—*Ischnodemus falicus,* nymph, dorsal aspect.
FIG. 176.—*Ischnodemus falicus,* adult, dorsal aspect.
FIG. 177.—*Ischnodemus falicus,* adult, cephalic aspect.
FIG. 178.—*Euryophthalmus succinctus,* nymph, dorsal aspect.
FIG. 179.—*Euryophthalmus succinctus,* nymph, cephalic aspect.
FIG. 180.—*Euryophthalmus succinctus,* adult, dorsal aspect.
FIG. 181.—*Myodochus serripes,* nymph, dorsal aspect.
FIG. 182.—*Myodochus serripes,* adult, dorsal aspect.

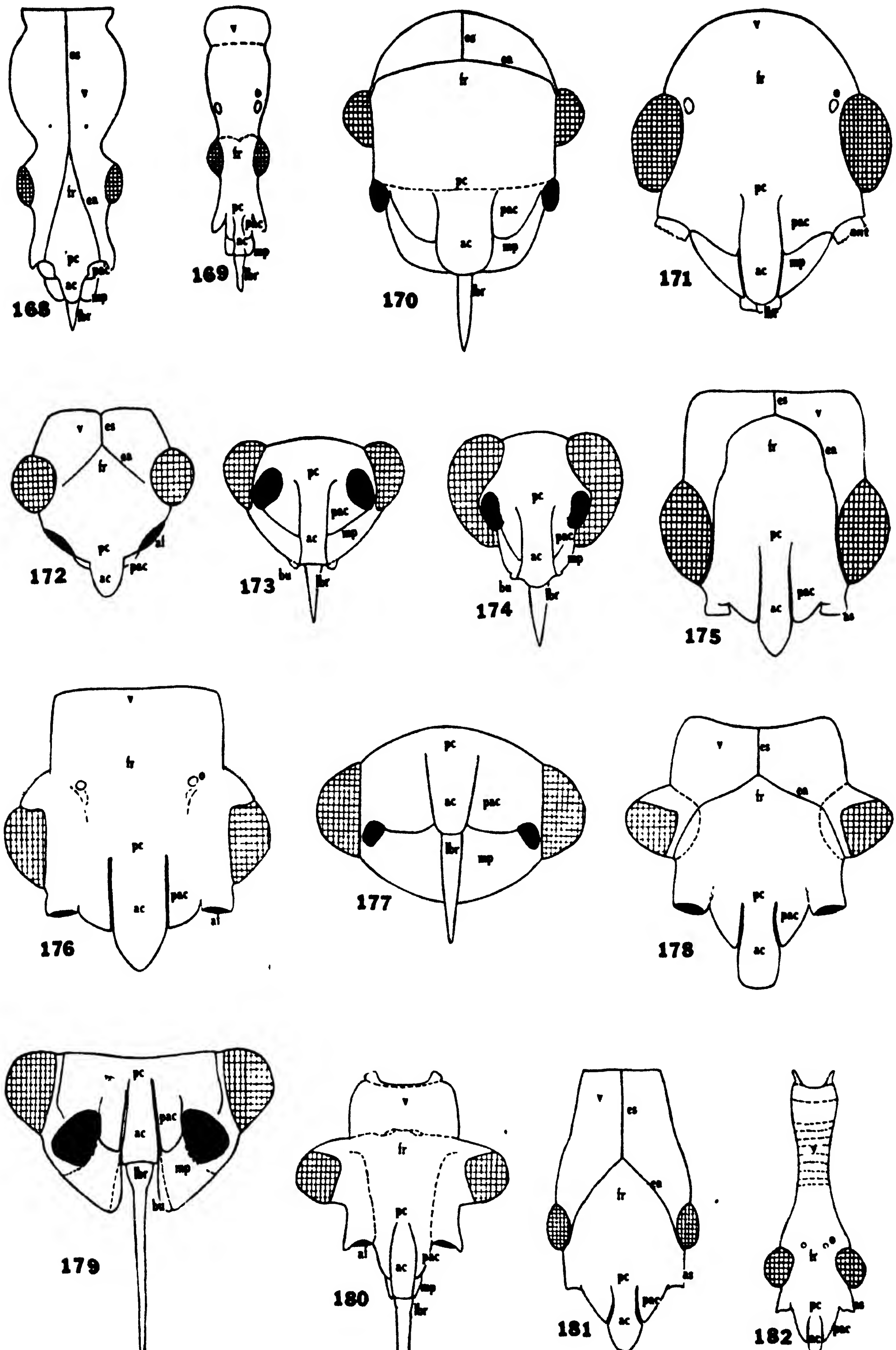

PLATE XI

PLATE XII

Dorsal and cephalic aspects of the head

FIG. 183.—*Myodochus serripes,* adult, cephalic aspect.
FIG. 184.—*Neides muticus,* nymph, cephalic aspect.
FIG. 185.—*Neides muticus,* adult, cephalic aspect.
FIG. 186.—*Neides muticus,* nymph, dorsal aspect.
FIG. 187.—*Neides muticus,* adult, dorsal aspect.
FIG. 188.—*Corizus* sp., nymph, dorsal aspect.
FIG. 189.—*Corizus* sp., adult, cephalo-dorsal aspect.
FIG. 190.—*Harmoestes reflexulus,* adult, dorsal aspect.
FIG. 191.—*Alydus* sp., nymph, cephalo-dorsal aspect.
FIG. 192.—*Alydus* sp., adult, cephalo-dorsal aspect.
FIG. 193.—*Leptocoris trivittatus,* nymph, dorsal aspect.
FIG. 194.—*Leptocoris trivittatus,* adult, cephalic aspect.
FIG. 195.—*Leptocoris trivittatus,* adult, dorsal aspect.
FIG. 196.—*Piesma cinerea,* adult, dorsal aspect.
FIG. 197.—*Corythuca ciliata,* nymph, dorsal aspect.
FIG. 198.—*Corythuca ciliata,* nymph, cephalic aspect.

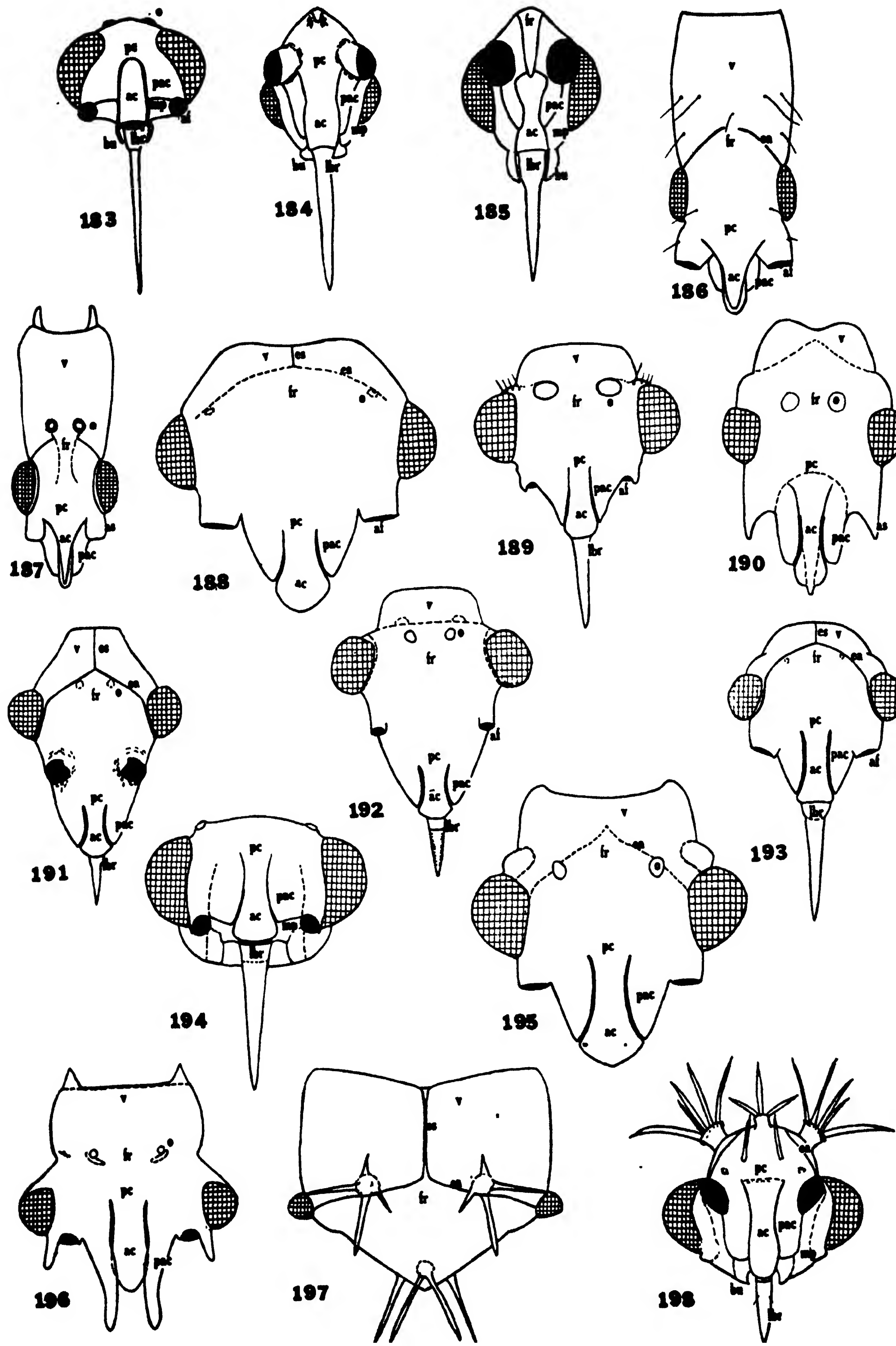

PLATE XII

PLATE XIII

Dorsal and cephalic aspects of the head

FIG. 199.—*Corythuca ciliata,* adult, cephalic aspect.
FIG. 200.—*Phymata* sp., nymph, dorsal aspect.
FIG. 201.—*Phymata* sp., adult, dorsal aspect.
FIG. 202.—*Phymata* sp., nymph, cephalic aspect.
FIG. 203.—*Phymata* sp., adult, cephalic aspect.
FIG. 204.—*Aneurus* sp., nymph, cephalic aspect.
FIG. 205.—*Ancurus* sp., adult, cephalic aspect.
FIG. 206.—*Aneurus* sp., nymph, dorsal aspect.
FIG. 207.—*Aneurus* sp., adult, dorsal aspect.
FIG. 208.—*Brochymena* sp., nymph, dorsal aspect.
FIG. 209.—*Brochymena* sp., adult, dorsal aspect.
FIG. 210.—*Stethaulax marmoratus,* adult, dorsal aspect.
FIG. 211.—*Corimelaena* sp., adult, dorsal aspect.
FIG. 212.—*Cyrtomenus mirabilis,* adult, dorsal aspect.

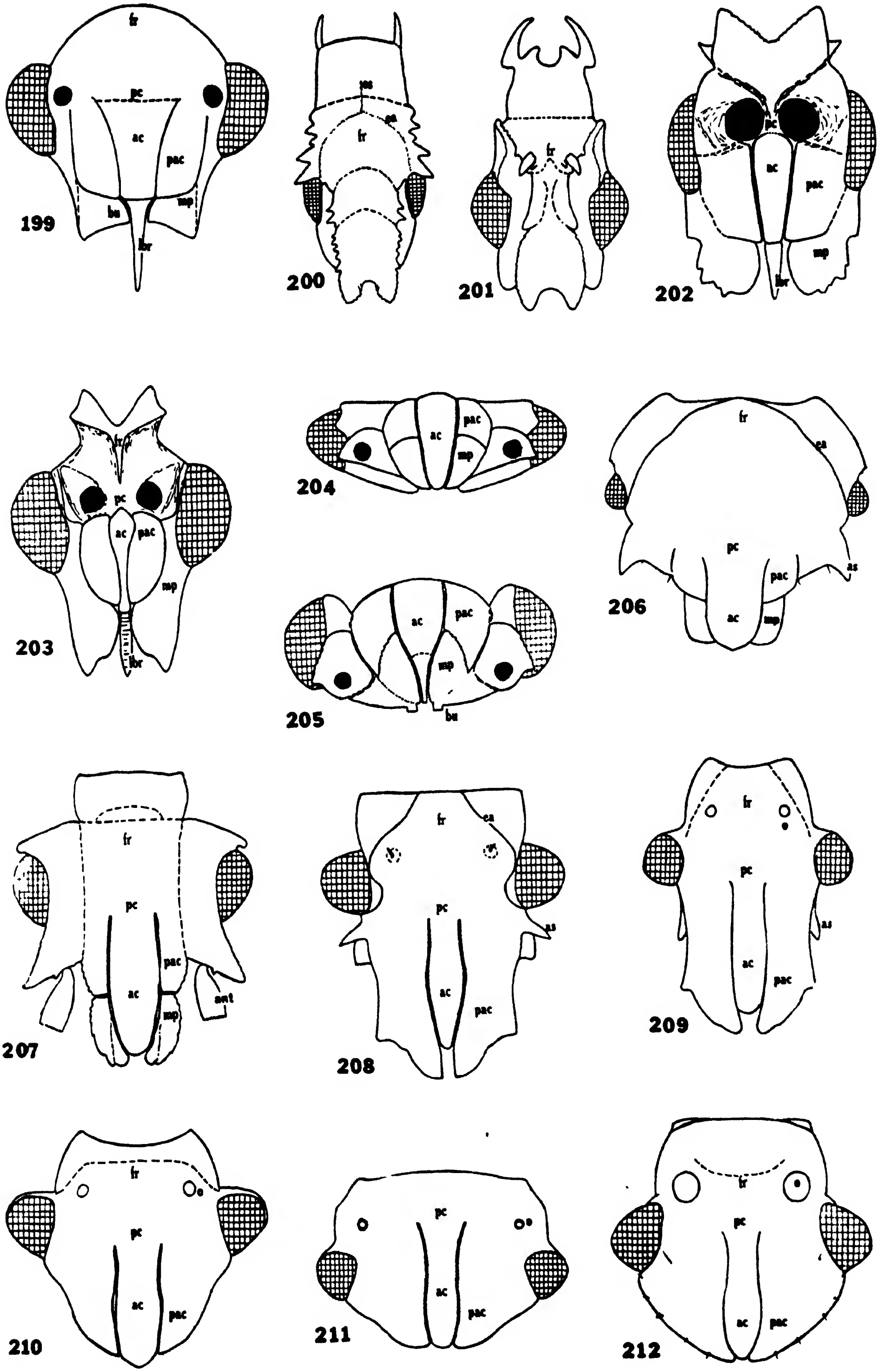

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PLATE XIII

PLATE XIV

Lateral aspect of the head

FIG. 213.—*Belostoma flumineum*, nymph.
FIG. 214.—*Belostoma flumineum*, adult.
FIG. 215.—*Ranatra americana*, adult.
FIG. 216.—*Ranatra americana*, nymph.
FIG. 217.—*Nepa apiculata*, nymph.
FIG. 218.—*Nepa apiculata*, adult.
FIG. 219.—*Pelocoris femoratus*, adult.
FIG. 220.—*Pelocoris femoratus*, nymph.
FIG. 221.—*Gerris marginatus*, nymph.
FIG. 222.—*Notonecta* sp., nymph.
FIG. 223.—*Notonecta* sp., adult.
FIG. 224.—*Corixa* sp., nymph.
FIG. 225.—*Corixa* sp., adult.
FIG. 226.—*Gerris marginatus*, adult.
FIG. 227.—*Rhagovelia obesa*, nymph.
FIG. 228.—*Rhagovelia obesa*, adult.
FIG. 229.—*Naeogeus burmeisteri*, adult.
FIG. 230.—*Mesovelia bisignata*, adult.
FIG. 231.—*Hydrometra martini*, adult.

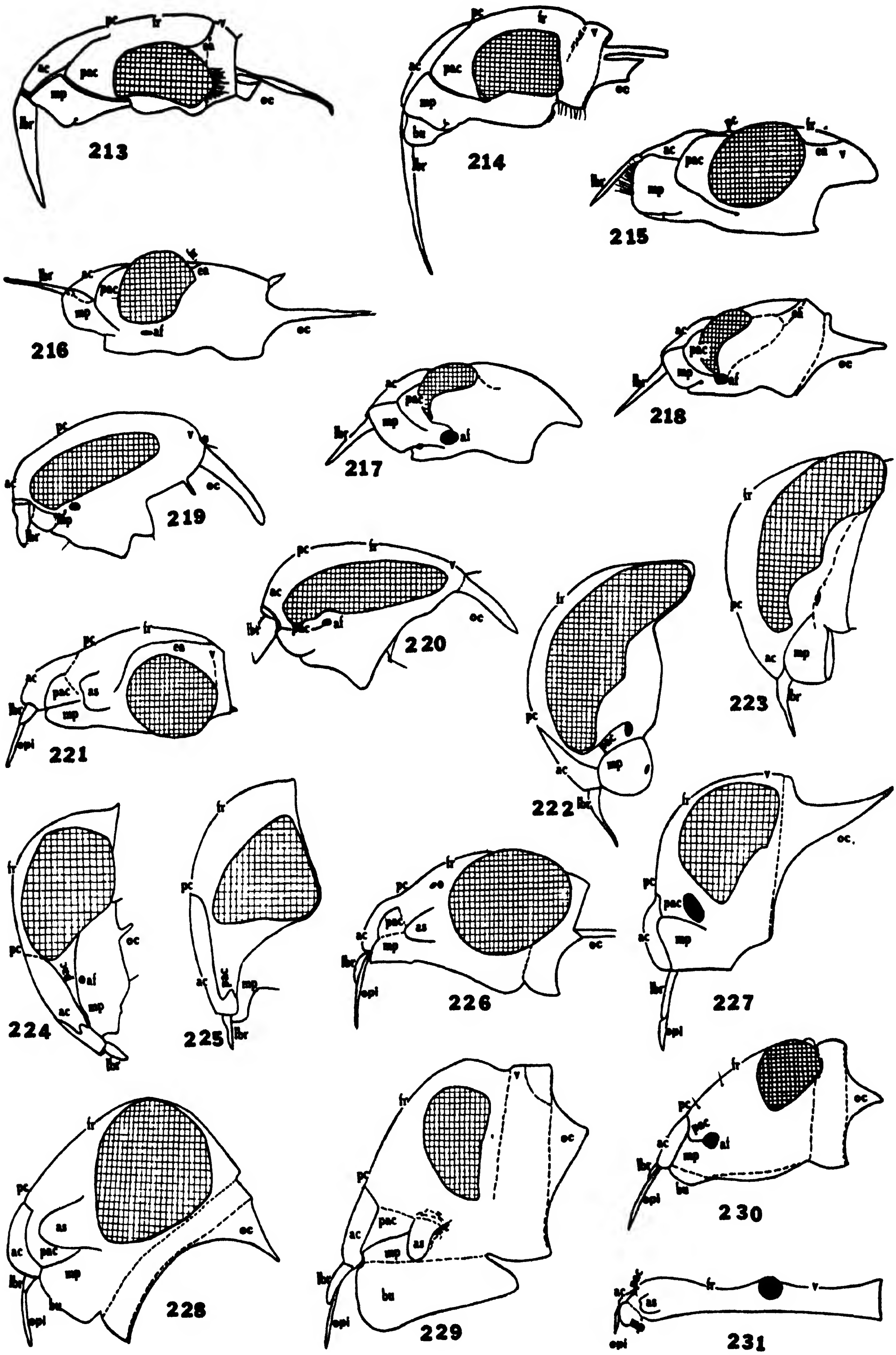
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PLATE XIV

PLATE XV

Lateral aspect of the head

FIG. 232.—*Ochterus americanus*, nymph.
FIG. 233.—*Ochterus americanus*, adult.
FIG. 234.—*Gelastocoris* sp., nymph.
FIG. 235.—*Cimex lectularius*, nymph.
FIG. 236.—*Gelastocoris* sp., adult.
FIG. 237.—*Cimex lectularius*, adult.
FIG. 238.—*Lamprocanthia* sp., adult.
FIG. 239.—*Triphleps insidiosa*, nymph.
FIG. 240.—*Triphleps insidiosa*, adult.
FIG. 241.—*Sinea* sp., nymph.
FIG. 242.—*Sinea* sp., adult.
FIG. 243.—*Emesa brevipennis*, nymph.
FIG. 244.—*Emesa brevipennis*, adult.
FIG. 245.—*Melanolestes abdominalis*, adult.
FIG. 246.—*Nabis subcoleoptratus*, adult.
FIG. 247.—*Nabis subcoleoptratus*, nymph.
FIG. 248.—*Systelloderus biceps*, nymph.
FIG. 249.—*Systelloderus biceps*, adult.
FIG. 250.—*Ceratocombus vagans*, nymph.

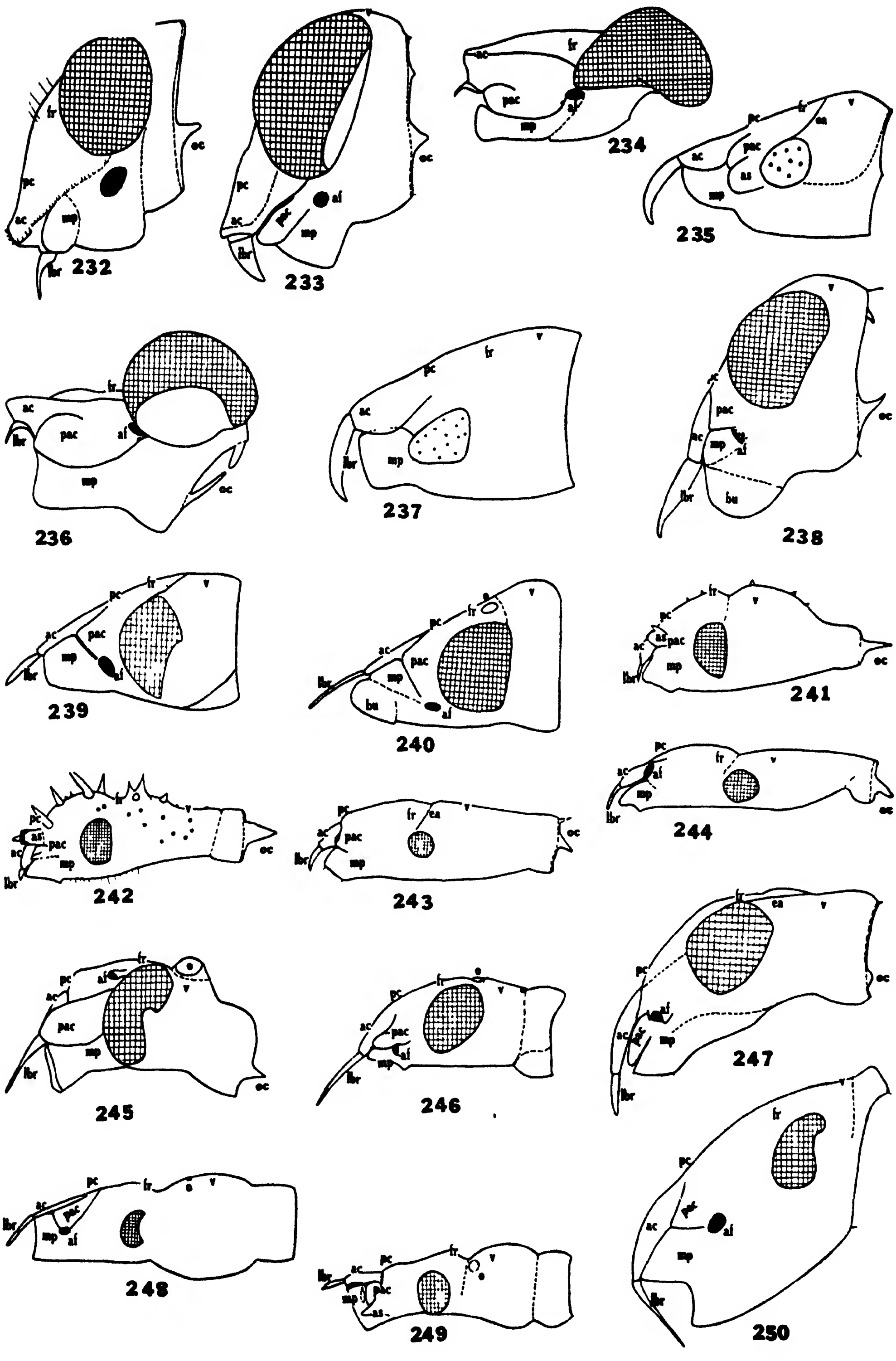
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PLATE XV

PLATE XVI

Lateral aspect of the head

FIG. 251.—*Ceratocombus vagans,* adult.
FIG. 252.—*Miris dolobrata,* adult.
FIG. 253.—*Adelphocoris rapidus,* adult.
FIG. 254.—*Ischnodemus falicus,* nymph.
FIG. 255.—*Ischnodemus falicus,* adult.
FIG. 256.—*Euryophthalmus succinctus,* nymph.
FIG. 257.—*Euryophthalmus succinctus,* adult.
FIG. 258.—*Myodochus serripes,* nymph.
FIG. 259.—*Myodochus serripes,* adult.
FIG. 260.—*Neides muticus,* nymph.
FIG. 261.—*Neides muticus,* adult.
FIG. 262.—*Corizus* sp., nymph.
FIG. 263.—*Alydus* sp., adult.
FIG. 264.—*Alydus* sp., nymph.
FIG. 265.—*Corizus* sp., adult.

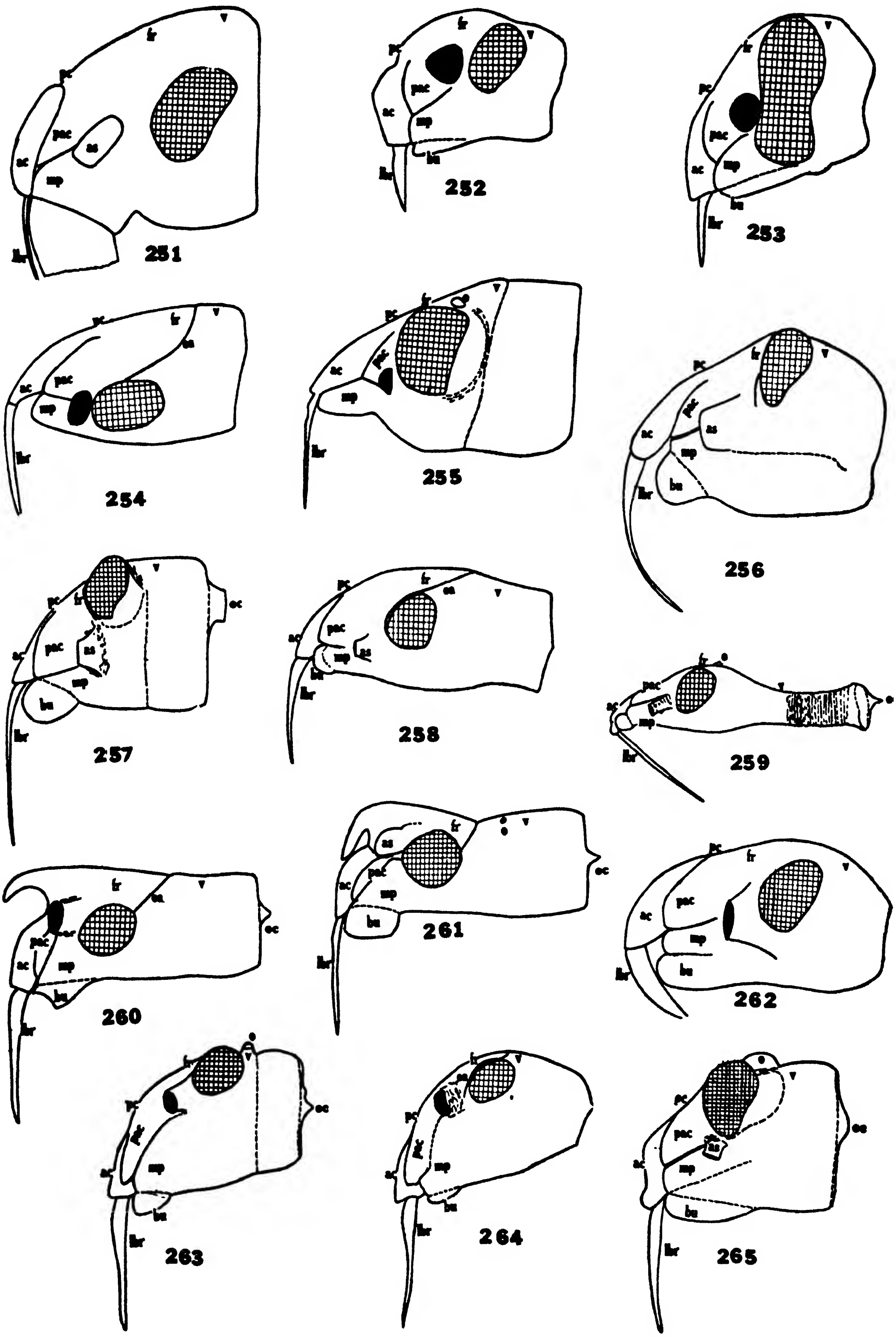

PLATE XVI

PLATE XVII

Lateral aspect of the head

FIG. 266.—*Harmoestes reflexulus*, adult.
FIG. 267.—*Leptocoris trivittatus*, adult.
FIG. 268.—*Leptocoris trivittatus*, nymph.
FIG. 269.—*Piesma cinerea*, adult.
FIG. 270.—*Corythuca ciliata*, nymph.
FIG. 271.—*Corythuca ciliata*, adult.
FIG. 272.—*Phymata* sp., nymph.
FIG. 273.—*Phymata* sp., adult.
FIG. 274.—*Aneurus* sp., nymph.
FIG. 275.—*Aneurus* sp., adult.
FIG. 276.—*Brochymena* sp., nymph.
FIG. 277.—*Brochymena* sp., adult.
FIG. 278.—*Corimelaena* sp., adult.
FIG. 279.—*Stethaulax marmoratus*, adult.
FIG. 280.—*Cyrtomoenus mirabilis*, adult.

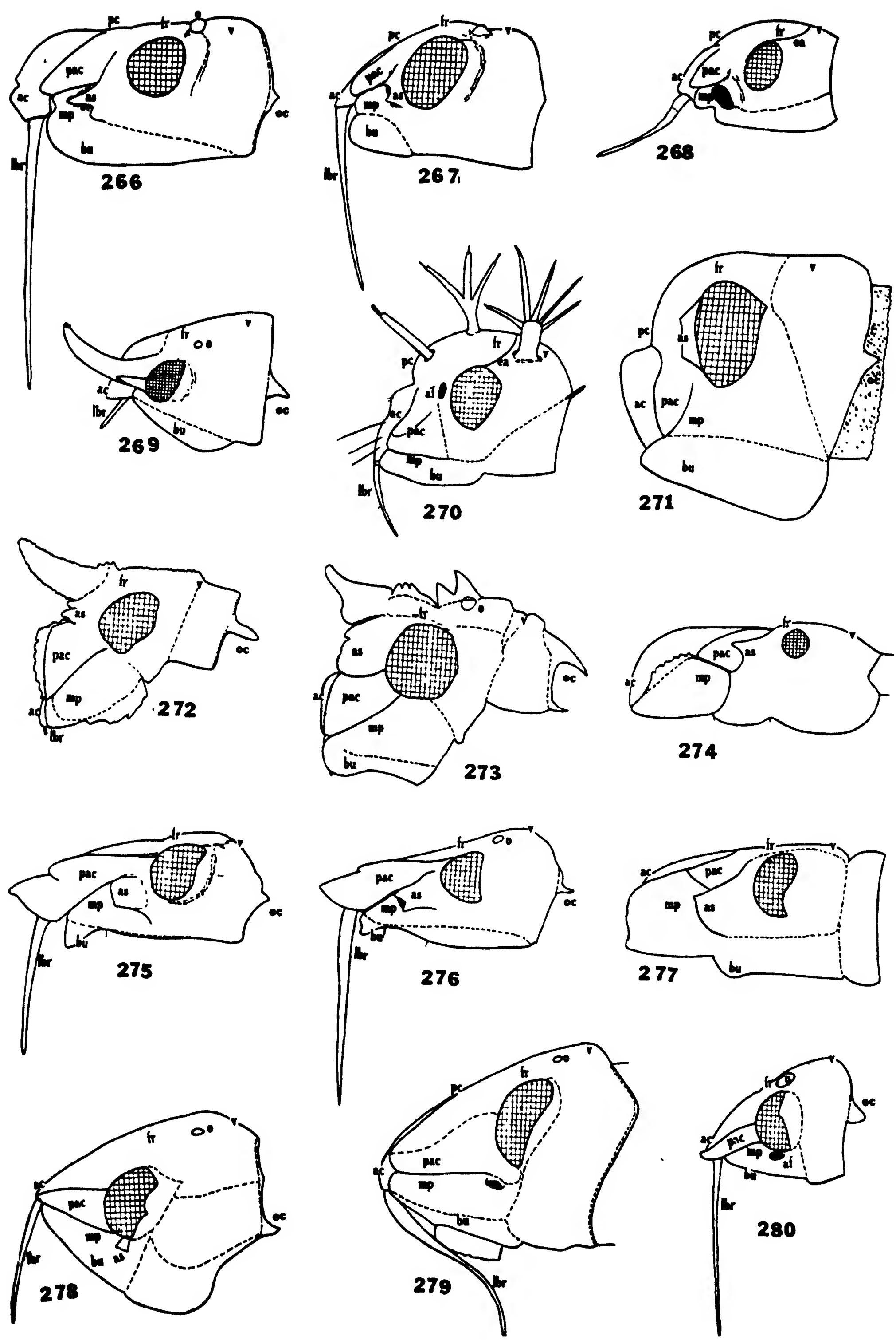
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PLATE XVII

PLATE XVIII

Ventral and caudal aspects of the head

FIG. 281.—*Belostoma flumineum,* nymph, ventral aspect.
FIG. 282.—*Belostoma flumineum,* adult, ventral aspect.
FIG. 283.—*Ranatra americana,* nymph, ventral aspect.
FIG. 284.—*Ranatra americana,* adult, ventral aspect.
FIG. 285.—*Nepa apiculata,* nymph, ventral aspect.
FIG. 286.—*Nepa apiculata,* adult, ventral aspect.
FIG. 287.—*Pelocoris femoratus,* nymph, ventral aspect.
FIG. 288.—*Pelocoris femoratus,* adult, ventral aspect.
FIG. 289.—*Notonecta* sp., adult, caudal aspect.
FIG. 290.—*Corixa* sp., adult, caudal aspect.
FIG. 291.—*Corixa* sp., nymph, caudal aspect.
FIG. 292.—*Gerris marginatus,* nymph, ventral aspect.
FIG. 293.—*Gerris marginatus,* adult, ventral aspect.

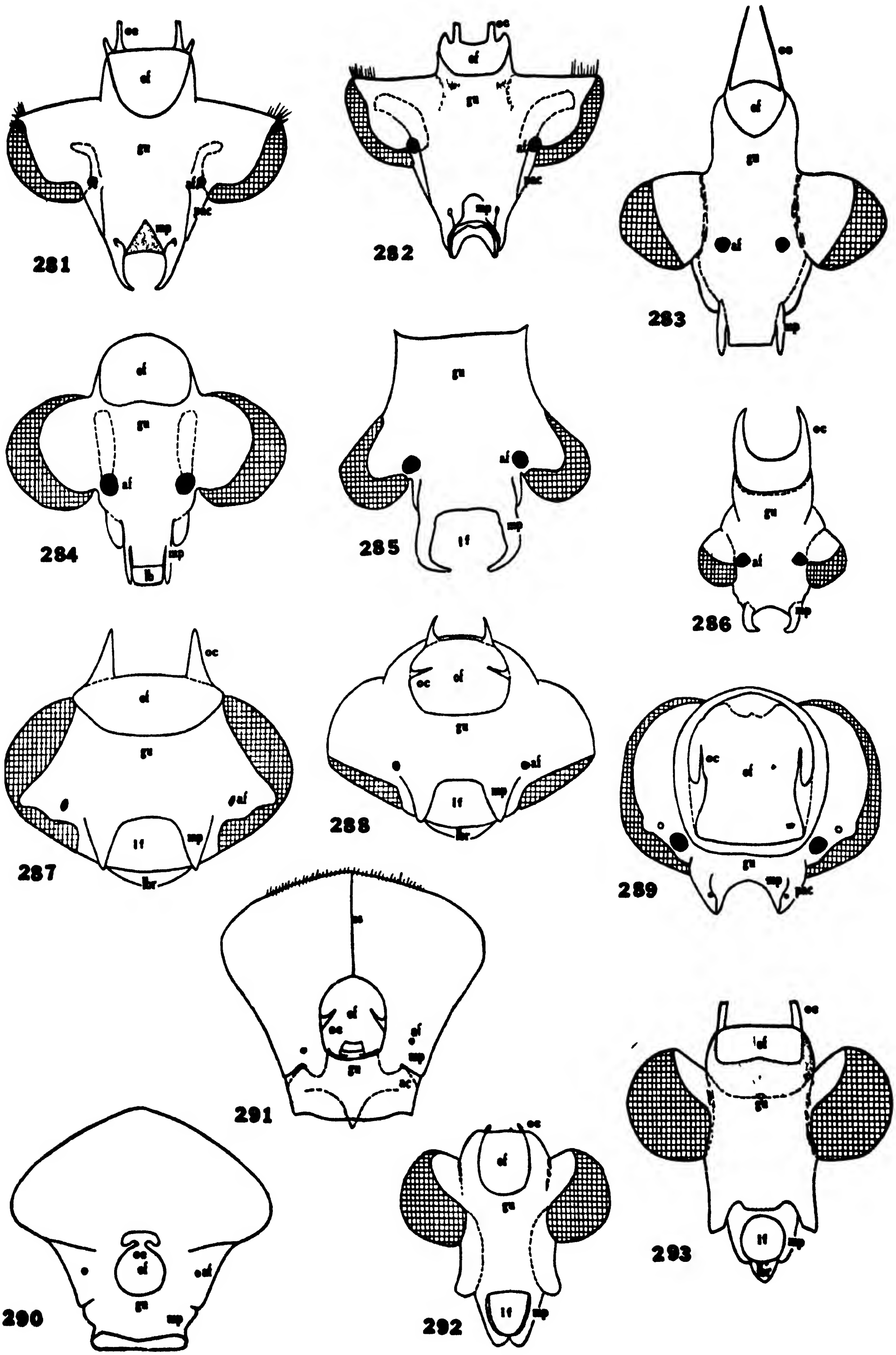

PLATE XVIII

PLATE XIX

Ventral and caudal aspects of the head

FIG. 294.—*Rhagovelia obesa,* adult, ventral aspect.
FIG. 295.—*Mesovelia bisignata,* adult, ventral aspect.
FIG. 296.—*Hydrometra martini,* adult, ventral aspect.
FIG. 297.—*Naeogeus burmeisteri,* adult, ventral aspect.
FIG. 298.—*Gelastocoris* sp., nymph, ventral aspect.
FIG. 299.—*Gelastocoris* sp., adult, ventral aspect.
FIG. 300.—*Gelastocoris* sp., nymph, caudal aspect.
FIG. 301.—*Gelastocoris* sp., adult, caudal aspect.
FIG. 302.—*Ochterus americanus,* adult, ventral aspect.
FIG. 303.—*Ochterus americanus,* nymph, caudo-ventral aspect.
FIG. 304.—*Ochterus americanus,* adult, caudal aspect.
FIG. 305.—*Lamprocanthia* sp., nymph, caudal aspect.
FIG. 306.—*Cimex lectularius,* nymph, ventral aspect.
FIG. 307.—*Cimex lectularius,* adult, ventral aspect.
FIG 308.—*Lamprocanthia* sp., adult, caudal aspect.
FIG. 309.—*Triphleps insidiosa,* adult, ventral aspect.
FIG. 310.—*Triphleps insidiosa,* nymph, ventral aspect.

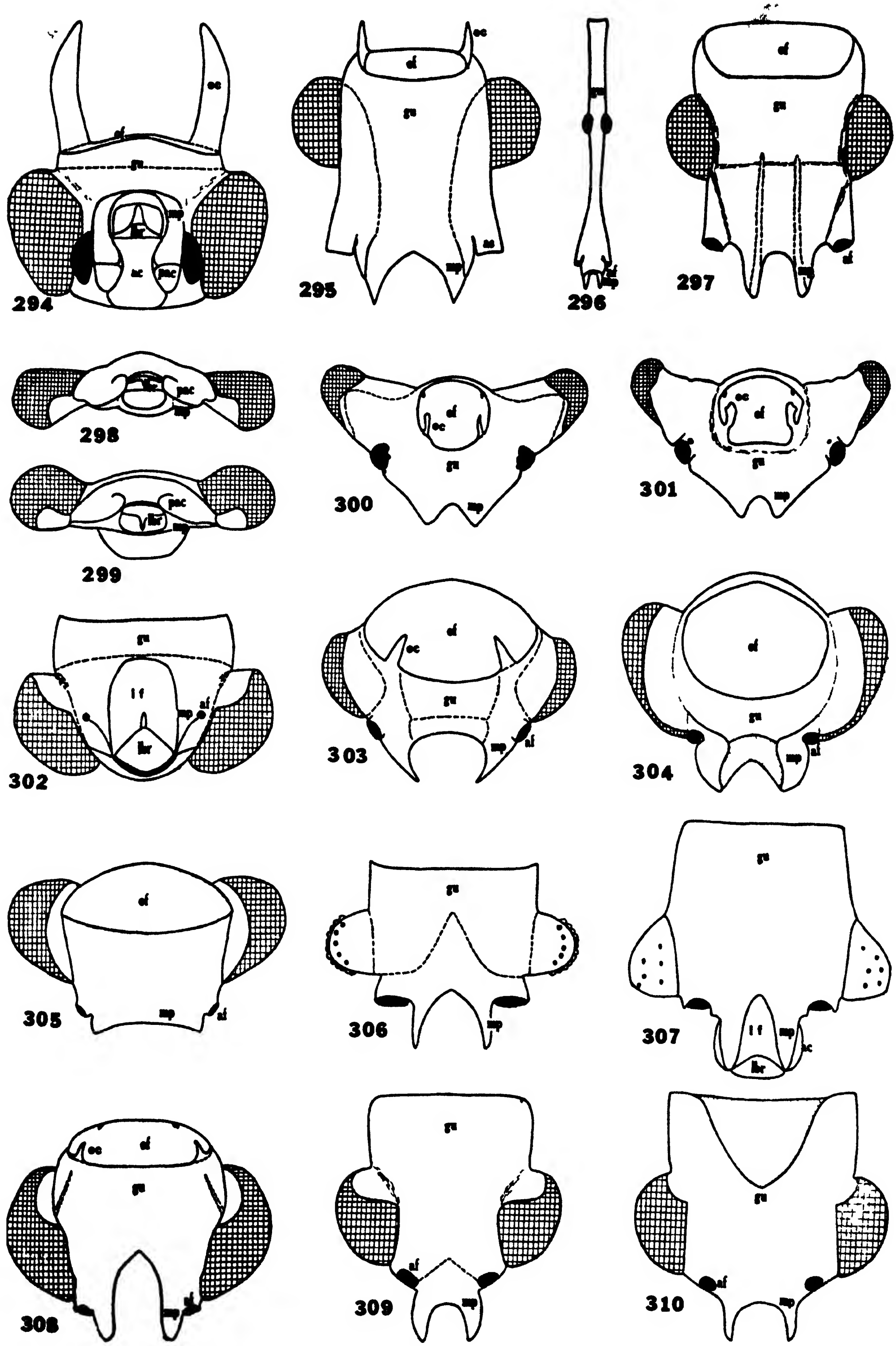
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PLATE XIX

PLATE XX

Ventral aspect of the head

FIG. 311.—*Sinea* sp., nymph.
FIG. 312.—*Sinea* sp., adult.
FIG. 313.—*Emesa brevipennis*, nymph.
FIG. 314.—*Emesa brevipennis*, adult.
FIG. 315.—*Melanolestes abdominalis*, adult.
FIG. 316.—*Nabis subcoleoptratus*, nymph.
FIG. 317.—*Nabis subcoleoptratus*, adult.
FIG. 318.—*Systelloderus biceps*, adult.
FIG. 319.—*Ischnodemus falicus*, nymph.
FIG. 320.—*Ischnodemus falicus*, adult.
FIG. 321.—*Euryophthalmus succinctus*, nymph.
FIG. 322.—*Euryophthalmus succinctus*, adult.
FIG. 323.—*Myodochus serripes*, nymph.
FIG. 324.—*Myodochus serripes*, adult.
FIG. 325.—*Neides muticus*, nymph.
FIG. 326.—*Neides muticus*, adult.
FIG. 327.—*Corizus* sp., nymph.
FIG. 328.—*Corizus* sp., adult.

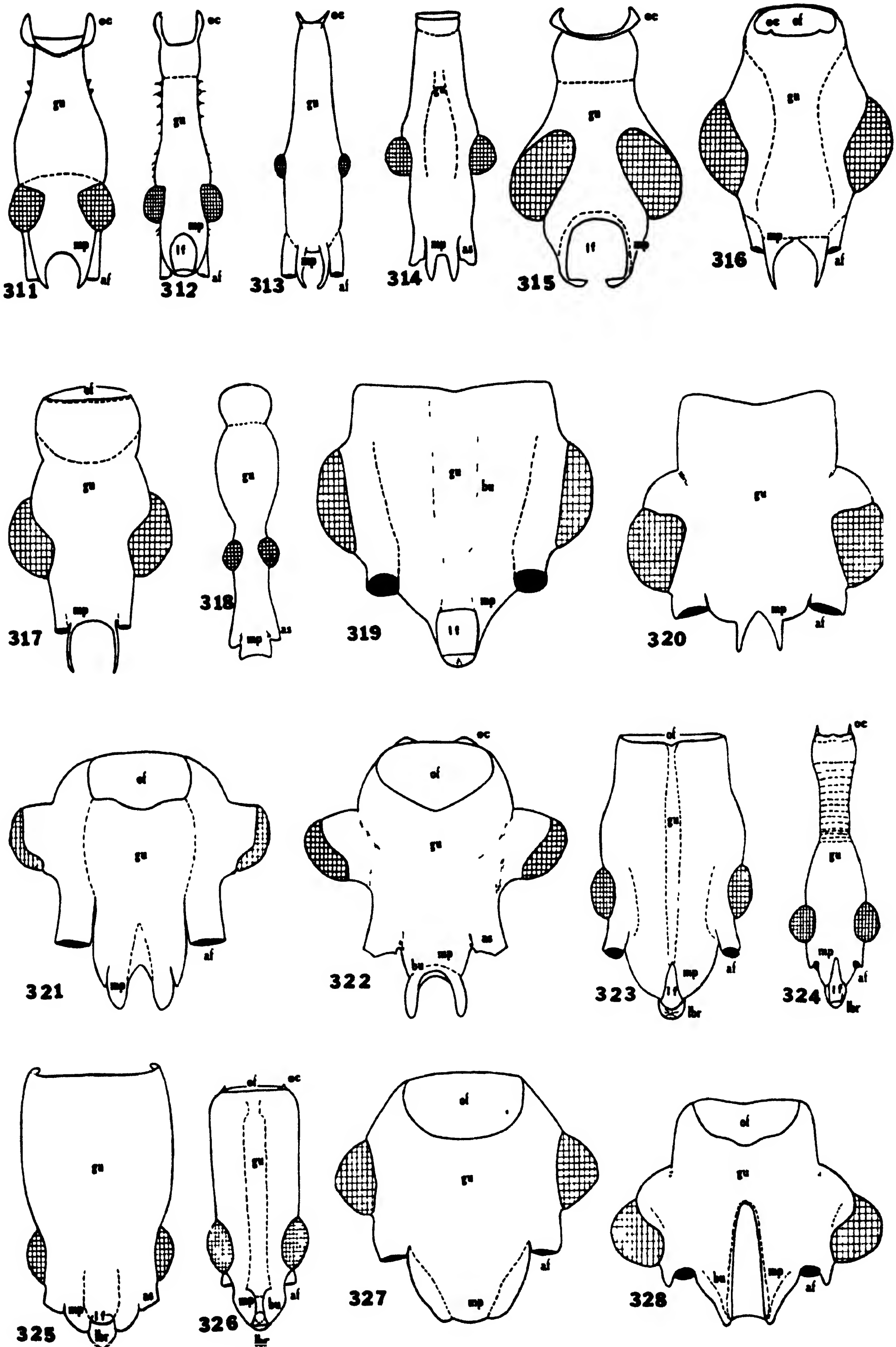

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PLATE XX

PLATE XXI

Ventral aspect of the head

FIG. 329.—*Harmoestes reflexulus,* adult.
FIG. 330.—*Alydus* sp., nymph.
FIG. 331.—*Alydus* sp., adult.
FIG. 332.—*Leptocoris trivittatus,* nymph.
FIG. 333.—*Leptocoris trivittatus,* adult.
FIG. 334.—*Piesma cineria,* adult.
FIG. 335.—*Corythuca ciliata,* nymph.
FIG. 336.—*Corythuca ciliata,* adult.
FIG. 337.—*Phymata* sp., nymph.
FIG. 338.—*Phymata* sp., adult.
FIG. 339.—*Aneurus* sp., nymph.
FIG. 340.—*Aneurus* sp., adult.
FIG. 341.—*Brochymena* sp., nymph.
FIG. 342.—*Brochymena* sp., adult.

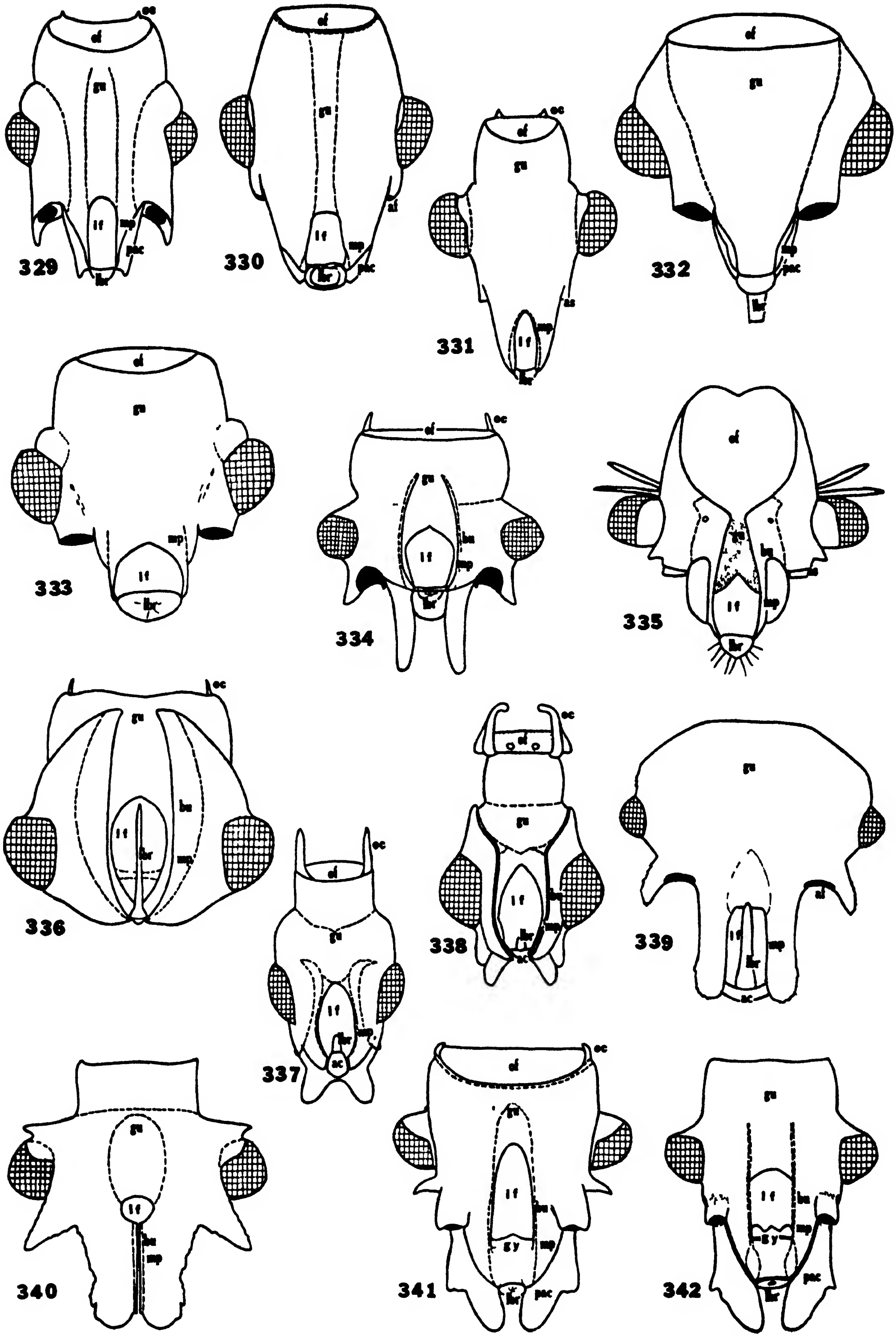

PLATE XXI

PLATE XXII

Ventral aspect of the head

FIG. 343.—*Cyrtomoenus mirabilis*, adult.
FIG. 344.—*Stethaulax marmoratus*, adult.
FIG. 345.—*Corimelaena*, adult.

Anteclypeus and labrum, lateral aspect

FIG. 346.—*Otiocerus wolfii*, adult.
FIG. 347.—*Belostoma flumineum*, adult.
FIG. 348.—*Euschistus tristigmus*, adult.

Mandible and lever

FIG. 349.—*Corixa* sp., adult.
FIG. 350.—*Otiocerus degeerii*, adult.
a. Marginal view.
FIG. 351.—*Lepyronia quadrangularis*, adult.
a. Marginal view.
FIG. 352.—*Tibicen sayi*, adult.
FIG. 353.—*Oncometopia undata*, adult.
FIG. 354.—*Belostoma flumineum*, nymph.
FIG. 355.—*Belostoma flumineum*, adult.
FIG. 356.—*Ranatra americana*, adult.
FIG. 357.—*Melanolestes abdominalis*, adult.
FIG. 358.—*Pelocoris femoratus*, adult.
FIG. 359.—*Notonecta* sp., adult.
FIG. 360.—*Gerris marginatus*, adult.
FIG. 361.—*Rhagovelia obesa*, adult.
FIG. 362.—*Mesovelia bisignata*, adult.
FIG. 363.—*Hydrometra martini*, adult.
FIG. 364.—*Naeogeus burmeisteri*, adult.

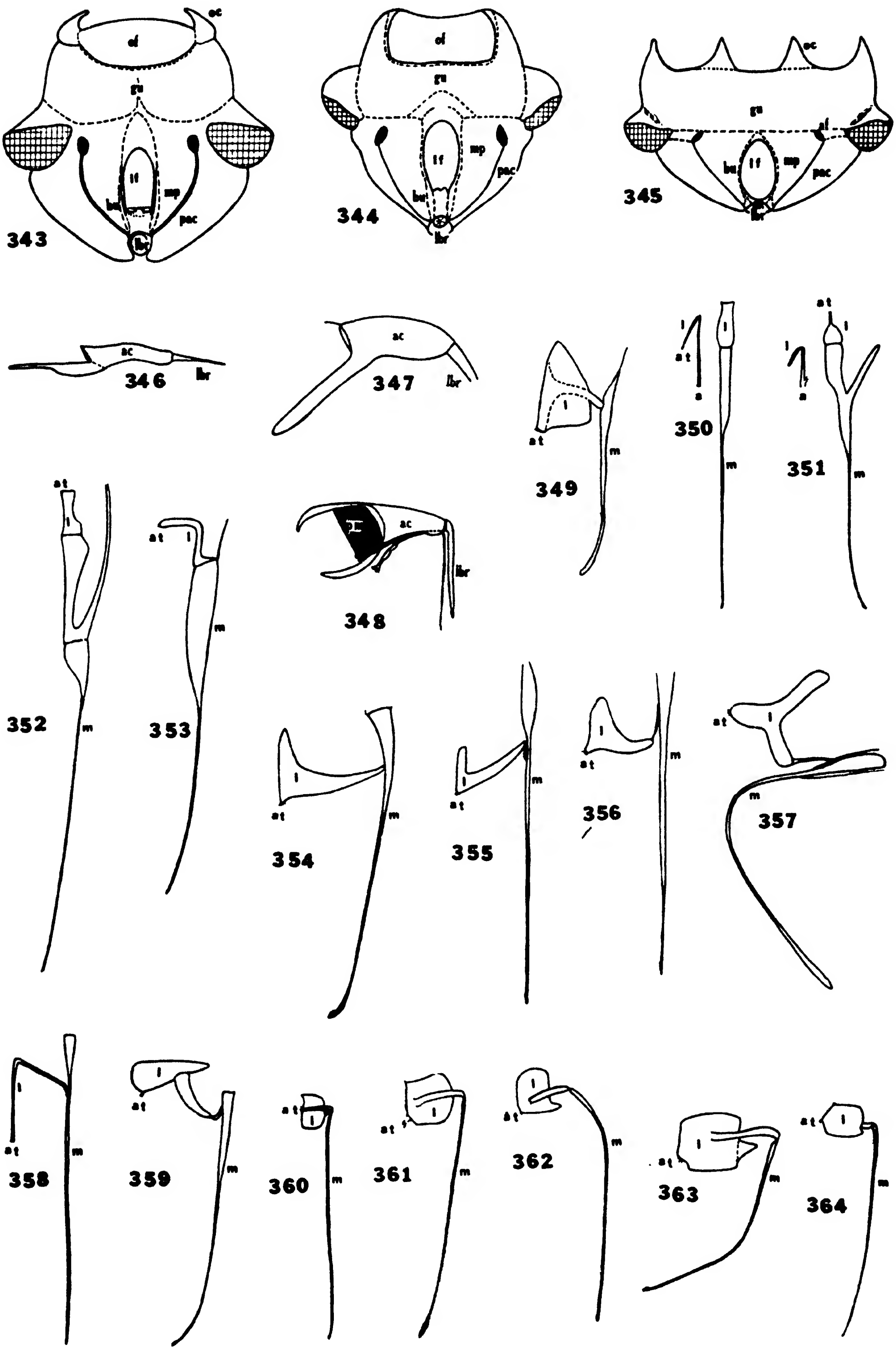
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PLATE XXII

PLATE XXIII

Mandible and lever

FIG. 365.—*Ochterus viridifrons,* adult.
FIG. 366.—*Ochterus americanus,* adult.
FIG. 367.—*Cimex lectularius,* adult.
FIG. 368.—*Gelastocoris* sp., adult.
FIG. 369.—*Pentocora* sp., adult.
FIG. 370.—*Sinea* sp., adult.
FIG. 371.—*Emesa brevipennis,* adult.
FIG. 372.—*Miris dolobratus,* adult.
FIG. 373.—*Adelphocoris rapidus,* adult.
FIG. 374.—*Ischnodemus falicus,* adult.
FIG. 375.—*Euryophthalmus succinctus,* adult.
FIG. 376.—*Myodochus serripes,* adult.
FIG. 377.—*Neides muticus,* adult.
FIG. 378.—*Jalysus spinosus,* adult.
FIG. 379.—*Corizus* sp., adult.
FIG. 380.—*Alydus* sp., adult.
FIG. 381.—*Anasa tristis,* adult.

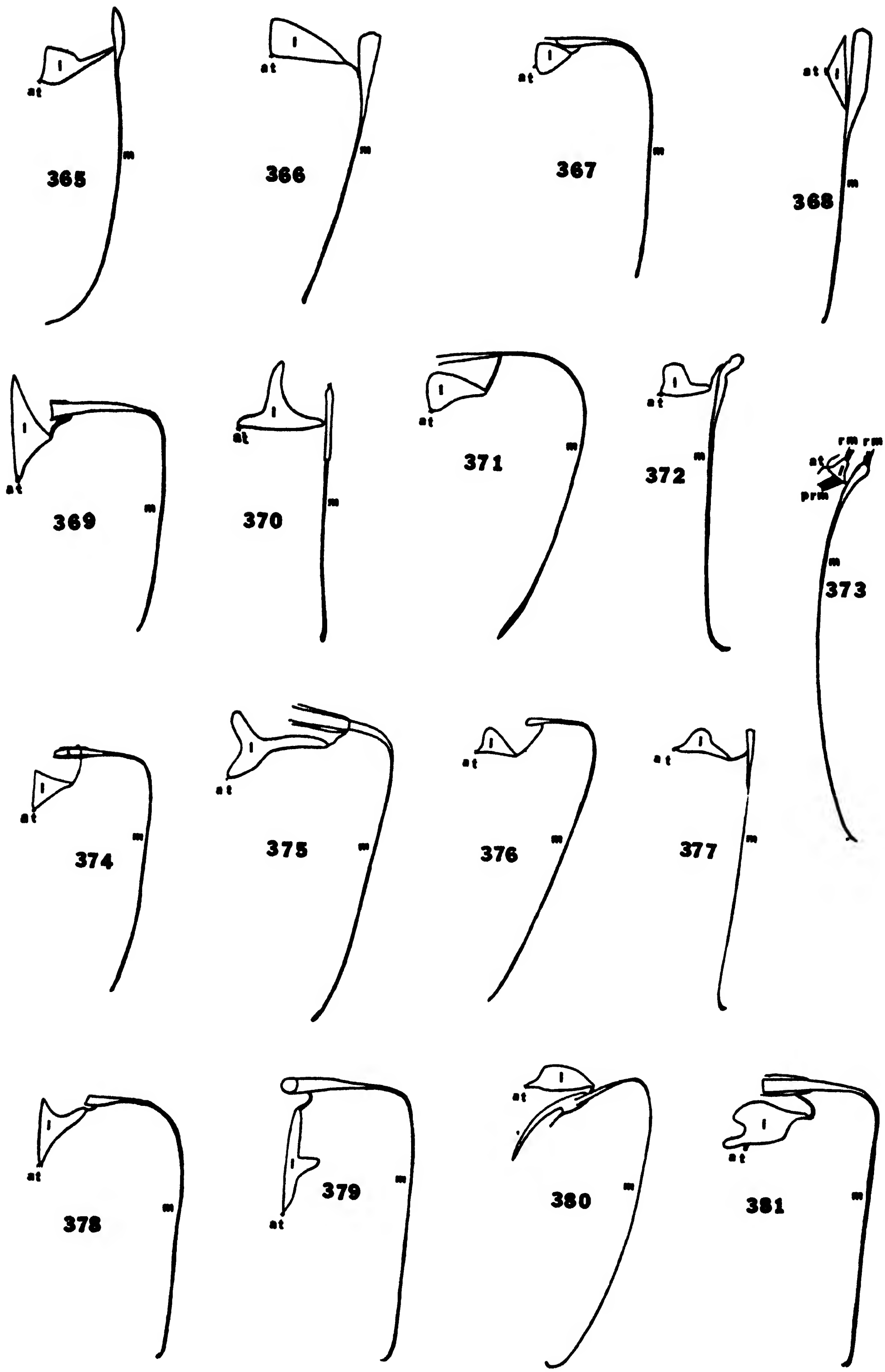
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PLATE XXIII

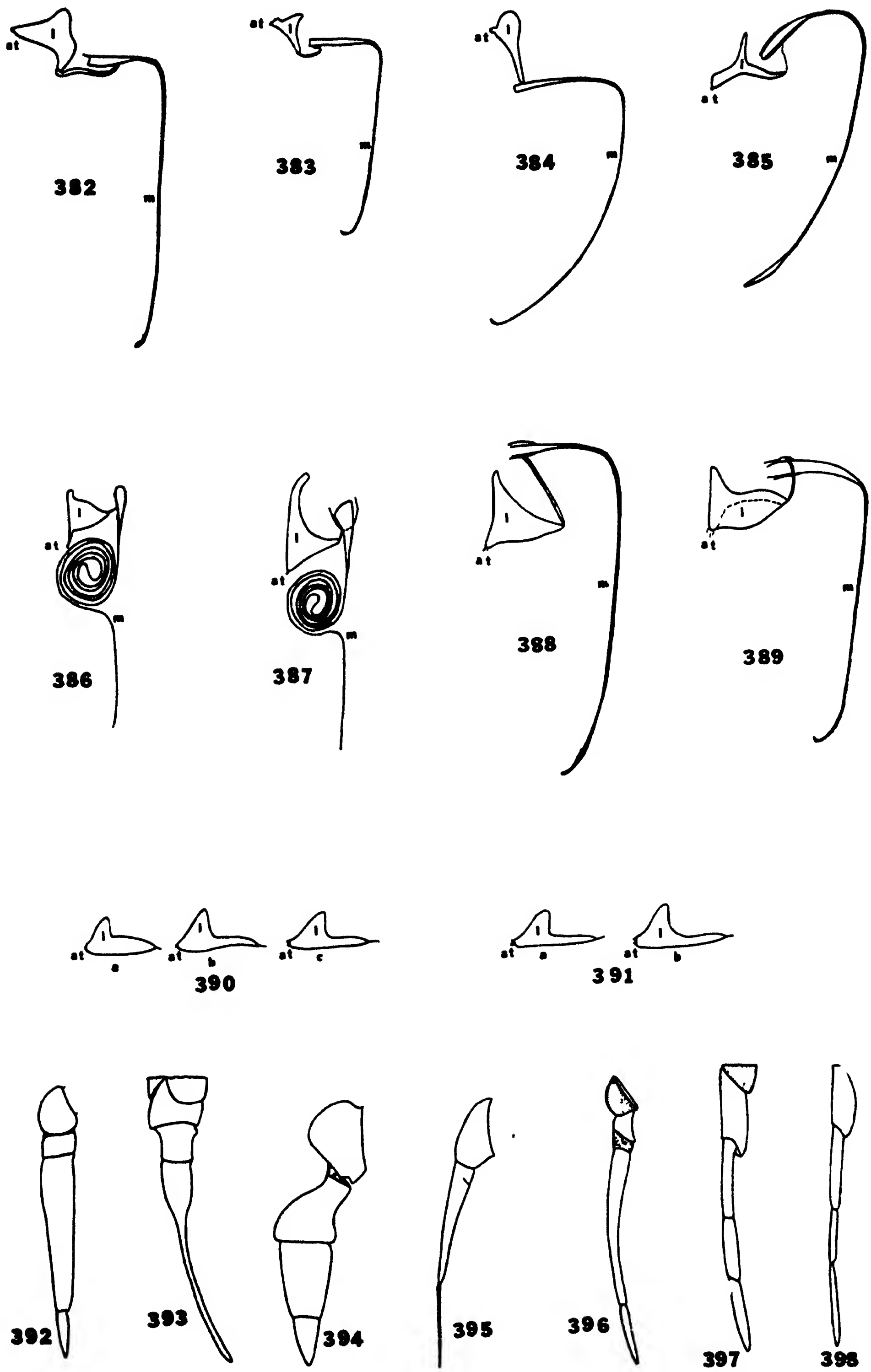
PLATE XXIV

Mandible and lever

FIG. 382.—*Acanthocephala terminalis*, adult.
FIG. 383.—*Piesma cinerea*, adult.
FIG. 384.—*Corythuca ciliata*, adult.
FIG. 385.—*Phymata* sp., adult.
FIG. 386.—*Aneurus* sp., nymph.
FIG. 387.—*Aneurus* sp., adult.
FIG. 388.—*Cyrtomoenus mirabilis*, adult.
FIG. 389.—*Stethaulax marmoratus*, adult.
FIG. 390.—a. *Euschistus servus*, adult, lever.
b. *Euschistus euschistoides*, adult, lever.
c. *Euschistus tristigmus*, adult, lever.
FIG. 391.—a. *Euschistus tristigmus luridus*, adult, lever.
b. *Euschistus servus* variety, adult, lever.

Labium

FIG. 392.—*Gerris remigera*, adult, lateral aspect.
FIG. 393.—*Ochterus americanus*, adult, lateral aspect.
FIG. 394.—*Gelastocoris* sp., adult, lateral aspect.
FIG. 395.—*Ceratocombus vagans*, adult, lateral aspect.
FIG. 396.—*Pentacora* sp., adult, lateral aspect.
FIG. 397.—*Miris dolobratus*, adult, lateral aspect.
FIG. 398.—*Adelphocoris rapidus*, adult, lateral aspect.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391
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395
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b
c

PLATE XXIV

INDEX

Acanalonia, 14
Acanalonia latifrons, 14, 17
Acinopterus acuminatus, 14, 20
Aleyrodidae, 22, 24, 43
Alydidae, 40, 44
Alydus sp., 31, 32, 33, 35
Amaloptera uhleri, 14, 17
Amphibicorises, 38, 39, 43, 44
Aneurus sp., 27, 28, 36
Anonycha, 38
Anteclypeus, 15, 16, 28
Anthocoridae, 39, 40, 41, 43
Aphididae, 21, 23, 24, 43
Aphrophorinae, 43
Apis, 19
Apterygota, 19
Aradidae, 35, 40, 41, 44
Auchenoryncha, 22, 24

Belostoma, 35, 36
Belostoma flumineum, 30, 31, 33
Belostomatidae, 31, 39, 41
Benacus, 33
Blatta, 19
Brochymena sp., 27, 28, 30, 31, 33, 35
Bruchomorpha, 14, 17
Bucculae, 30, 40

Carynota mera, 15, 17, 20
Catonia impunctata, 15, 17
Caudal aspect of the head, Homoptera, 18
Ceratocombus vagans, 8, 31
Cercopidae, 19, 22, 24, 43
Ceresa, 20
Cicadellidae, 22, 23, 24, 43
Cicadidae, 20, 22, 23, 43
Cimex lectularius, 26, 28, 29, 31
Cimicidae, 31, 39, 40, 43
Cixiidae, 24
Clypeal region, Homoptera, 15
  Heteroptera, 28
Coccidae, 22, 43
Coreidae, 41
Corimelaena sp., 30
Corimelaenidae, 40, 44
Corixa sp., 27, 29, 31, 36
Corixidae, 31, 38
Corizidae, 40, 44
Corizus sp., 30
Corpotentorium, 19, 20
Corydalis, 15
Corythuca ciliata, 30, 31
Cryptocerata, 28, 38
Cryptostemmatidae, 40, 44
Cyarda melichari, 14, 17
Cydnidae, 40, 44
Cyrtomenus mirabalis, 30

Dictyophora florens, 14
Diptera, 18

Emesa brevipennis, 27, 28, 31, 35
Emesidae, 40
Enicocephalidae, 40, 44
Ephemerida, 19
Epipharynx, Homoptera, 18
  Heteroptera, 31
Epiptera, 14, 17
Erythroneura comes, 14, 20
Eugereon, 11, 25
Euryophthalmus succinctus, 27, 32
Euscelis bicolor, 17, 20
Euschistus, 37
Euschistus tristigmus, 37

Frons, Homoptera, 14
  Heteroptera, 28
Fulgoridae, 12, 13, 22, 23, 24, 37, 43

Gelastocoris sp., 29, 31, 36
Generalized head, 10
Geocorises, 38, 40, 43, 44
Gerridae, 32, 37, 39
Gerris marginatus, 27, 32, 33, 36
Gerris remigus, 37
Gula, 18, 32
Gymnocerata, 28, 38
Gypona, 14

Harmoestes reflexulus, 32
Hemimaxillae, 17
Hemiodoecus leai, 21
Heteroptera, 11, 23, 24
Homoptera, 11
Hydrobiotica, 38
Hydrocorises, 38, 39, 40, 43
Hydrometra martini, 30
Hydrometridae, 39, 41
Hypopharynx, 18, 19

Ischnodemus falicis, 28
Issidae, 23

Jassus olitorius, 14, 20
Jugae, 27

Labial suture, 17
Labium, Heteroptera, 34
Homoptera, 21
Labrum, Heteroptera, 31
Homoptera, 18
Labrum-epipharynx, 18
Lachnini, 21
Lachnus, 14
Lamenia, 14, 16
Lamprocanthia, 26, 29, 30, 31, 34
Leptocoris trivittatus, 32
Lepyronia quadrangularis, 14, 15, 17, 19, 22, 23
Liburniella ornata, 14
Lygaeidae, 41, 44

Mandibular levers, 21, 35
Maxillary levers, 22
Maxillary plates, Heteroptera, 30
Homoptera, 22
Maxillary process, 18
Maxillary setae, 37
Maxillary suture, 17
Melanolestes abdominalis, 31, 33, 35, 36
Membracidae, 20, 22, 24, 43
Mesovelia bisignata, 36
Mesoveliidae, 32, 39, 41
Metatentoria, 17, 19, 20
Metatentorina, 18
Microphysidae, 41
Miridae, 40, 44
Miris dolobratus, 31
Monecophora bicincta, 14, 17, 19, 23
Myodochus serripes, 28, 32
Myriapoda, 19

Nabidae, 31, 40, 44
Nabis subcoleoptratus, 27, 30, 31, 35
Naeogeidae, 32, 39, 41
Naeogeus burmeisteri, 32, 36
Naucoridae, 29, 31, 39, 43
Naucoris, 35
Naucoris cimicoides, 7
Neides muticus, 28, 29, 30, 31, 32, 35
Neididae, 40, 41, 44
Nepa, 35
Nepidae, 39, 41
Nerthridae, 29, 32, 39, 41, 44
Notonecta sp., 29, 30, 31, 35, 36
Notonectidae, 29, 31, 39, 43

Ochteridae, 29, 32, 39, 41, 44
Ochterus americanus, 29, 33, 36, 37
Ochterus viridifrons, 36, 37
Odonata, 19
Odontoidea, 18
Oecleus borealis, 13, 15
Oncometopia undata, 14, 20, 23
Onychiopoda, 38
Ormenis pruinosa, 14
Otiocerus degeerii, 12, 14, 15, 16, 21, 29, 37
Otiocerus wolfii, 16, 29, 37

Pachypsylla celtidis-mamma, 14, 21, 22
Pagiopoda, 38
Paraclypeus, 15, 16, 28
Pelitropis rotatula, 14, 17
Pelocoris, 35, 36
Pelocoris femoratus, 29, 30, 31, 33
Peloridiidae, 21
Peltocephala, 38
Pentagramma vittatifrons, 14
Phlepsius excultus, 20
Phylogeny, Heteroptera, 37
Homoptera, 22
Phymata, 29, 30, 33, 35
Phymatidae, 40
Piesma cineria, 35
Piesmidae, 40, 41, 44
Poekillopteridae, 23
Polyneura, 38
Postgenae, 17
Postclypeus, 15, 16, 28
Postoccipital suture, 17
Pretentorium, 19, 20
Pristhesancus papuensis, 29
Protohomoptera, 23
Psylla mali, 7, 22
Psyllidae, 22, 23, 24, 43
Pterygota, 19
Pyrrhocoridae, 40, 41, 44
Pyrops candelaria, 21

Ranatra, 35
Ranatra americana, 30, 33
Reduviidae, 31, 40, 44
Reduvius personatus, 28
Rhagovelia obesa, 32, 36

Saldidae, 25, 31, 34, 40, 41
Sandaliorrhyncha, 38, 43
Scolops, 13
Scutelleridae, 41
Sinea sp., 27, 31, 35
Sternorhyncha, 22
Stethaulax marmoratus, 30, 31, 33, 35
Supratentorium, 19, 20
Systellodorus biceps, 31, 35

Tentorium, Heteroptera, 33
  Homoptera, 18
Termatophylidae, 41
Tettigonidae, 43
Thaumasticoridae, 41
Thyreocoridae, 41
Tibicen sayi, 14, 15, 20, 22, 23
Tingitidae, 31, 40, 44
Trachalopoda, 38
Trioza tripunctata, 14
Triphleps insidiosa, 26, 27, 31, 33, 34

Veliidae, 32, 39, 41
Vertex, Heteroptera, 27
  Homoptera, 13

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PRESS

A CLASSIFICATION OF THE LARVAE AND PUPARIA OF THE SYRPHIDAE OF ILLINOIS EXCLUSIVE OF AQUATIC FORMS

WITH SEVENTEEN PLATES

BY

ELIZABETH M. HEISS

CONTRIBUTION FROM THE ENTOMOLOGICAL LABORATORY OF THE
UNIVERSITY OF ILLINOIS
No. 187

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CONTENTS

Introduction 9

Historical Account 9

Family Characteristics of Immature Syrphidae 10

Egg 10

Larva 11

Puparium 14

Food Habits and Pupariation 15

Evidence of Generic Relationships Afforded by the Larvae . . 17

Parasites 18

Other Larvae Resembling Syrphidae 19

Taxonomy 20

Glossary 20

Key to the Known Genera 21

Larvae 21

Puparia 24

Descriptions and Keys to Species 27

Allograpta 27

Sphaerophoria 28

Mesogramma 30

Melanostoma 34

Platychirus 36

Lasiophthicus 38

Eupeodes 40

Syrphus 42

Metasyrphus 49

The *emarginatus* group ("Metasyrphus") 57

Epistrophe 63

Pipiza 65

Paragus 70

Descriptions and Keys to Species *(continued)*.
Didea 72
Baccha 73
Chrysotoxum 75
Xanthogramma 76
Xylota 77
Temnostoma 81
Merodon 83
Eumerus 85
Syritta 89
Brachypalpus 91
Tropidia 94
Brachyopa 95
Volucella 96
Microdon 96
Cerioides 97

Appendix: List of Known Parasites 99

Bibliography 101

Plates 105

Index 140

INTRODUCTION

The trend in recent years towards recognition of the necessity and value of studies in the immature taxonomy of insects has produced a number of useful papers on the classification of immature insects. However, there remains much to be done. During the course of a year's study of immature insects with Dr. William P. Hayes at the University of Illinois, the author was impressed with the need for more compact and comprehensive studies in many orders and the need for pioneer work in other orders where keys, if they exist at all, apply only to relatively small groups of families or genera.

In the Diptera, whose larvae are perhaps the most varied in form and habit of those of any order, the classification of immature Orthorrhapha by J. R. Malloch provides the student of the order with an excellent working tool. In the Cyclorrhapha, however, the student has no aid in many groups at all; the larvae are little known, or described in widely scattered papers.

The writer chose the Syrphidae, although some keys already were available for this family, in part because the members of this family are abundant in the region where this work was carried on and in part because of their interest as a transitional group with variable habits. A few forms, such as the rat-tailed maggot, were described very early in entomological history, and numerous accounts of immature syrphids may be found scattered through the literature up to the present time. It has been the author's purpose to bring together and make available all the additional information from the literature which might extend her own studies and contribute to the knowledge of the immature syrphids of this region. Soon after this study was begun, Dr. O. A. Johannsen of Cornell published his "Aquatic Diptera, Part II" (1935) in which was included the known immature stages of Syrphidae found in water. The aquatic forms have been omitted from the present paper for this reason.

Since our knowledge is still far from complete, and the immature stages of many species and even genera are unknown, the keys which follow must be regarded as tentative. If this study provides a better means of identifying the immature stages than has heretofore been available and brings forth some information on the relationships of the genera within this family, the author will be well repaid.

HISTORICAL ACCOUNT

Only the more important and comprehensive accounts will be considered here. The pioneer work was done by Dr. C. L. Metcalf. Between 1911 and 1913 he published in *The Ohio Naturalist* a series of five articles

giving very complete studies of a number of syrphid life histories. In 1913 these were condensed and combined into one paper containing a key to the then known species, "The Syrphidae of Ohio," published in *The Ohio Biological Survey.* This paper contains the first attempt to classify the immature Syrphidae. In 1916 and 1917, Metcalf published two additional series of detailed studies, "The Syrphidae of Maine" and "The Syrphidae of Maine—Second Report," but only the former contains a key. The excellently illustrated "Contributions to the Biology of North American Diptera" by Charles T. Greene (1917, 1923a) contain two series of descriptions of Syrphidae, most of which are among the rarer species. Jones (1922) described immature forms from Colorado, and Campbell and Davidson (1924) from California, but neither of these accounts is more than a series of descriptions. In 1929, Fluke made an interesting attempt to classify the larvae of this family which attack the pea aphid on the basis of the characters of the posterior respiratory process alone. This key is restricted to a portion of the aphidophagous species which occur in the Illinois region. In 1933, a paper by Vimmer appeared with keys to the larvae and puparia of Czechoslovakian syrphids, but in this case, descriptions are lacking. The keys and descriptions of Johannsen (1935) cover what is known of aquatic syrphids and supplement the paper presented here.

With the exception of Vimmer's paper and some of the descriptions of Greene for species which have not been recorded for Illinois, the above papers have been found very useful in this contribution to the taxonomy of immature Syrphidae.

FAMILY CHARACTERISTICS OF IMMATURE SYRPHIDAE

Egg

The eggs of this family which have been seen by the writer (chiefly those of aphidophagous species and of *Mesogramma polita,* the corn-feeding syrphid fly) have all been very similar. They are about a millimeter long by one-fourth millimeter wide, subcylindrical, tapering slightly at the ends, and slightly curved lengthwise. The micropilar end is somewhat blunter than the opposite pole. The egg is milky white or greyish white and covered with a fine raised reticulation, composed of minute elevations with radiating arms branching out to adjoining elevations. The patterns of the sculpturing vary somewhat in different species.

The eggs of the saprophytic forms, *Tropidia* and *Syritta,* according to Metcalf (1916) and of *Helophilus* according to Jones (1922), are also white and oval, but the sculpturing is described as small polygonal areas, slightly raised, with narrow parallel-sided channels between them, forming a fine dark network over the surface of the egg.

The eggs of aphidophagous species are usually laid singly, among or near aphid colonies on the leaf surface or along the stem of the plant where the aphids are found. In the genera *Melanostoma* and *Platychirus* and in *Mesogramma polita,* a few eggs are laid side by side on the plant in little groups of four or five. *Syritta pipiens* and *Tropidia quadrata* lay eggs in masses of one hundred or more (Metcalf, 1916).

The eggs have not been considered in this classification.

Larva

The larvae of the family Syrphidae are distinguished from the larvae of all other cyclorrhaphous families by two characters: (1) The two posterior respiratory tubes are always contiguous and more or less completely fused except in first instar larvae and in the single species, to the writer's knowledge, *Mesogramma polita.* (2) Each body segment bears twelve segmental spines in definite positions. The single known exception to this condition is that of the remarkable mollusc-like larva of *Microdon,* in which it is not possible to distinguish any segmentation and in which segmental spines appear to be missing as well. All of the larvae of Syrphidae in the writer's possession which were sufficiently well preserved for dissection, were found to possess a set of extrusible sac-like organs opening into the rectum, which are referred to as the rectal gills. In the aphidophagous species, they are small and remarkably similar, but they are highly developed in the saprophytic forms and most elaborate in those whose habitat is aquatic. Gäbler (1932) has used them as a means of differentiation between species of *Eristalis.* Rectal gills appear to be typical of the Syrphidae, but whether they are present extensively in other families, the writer is unable to say. Alsterberg (1934) has analyzed the respiratory structures of a number of aquatic syrphid larvae and states that the rectal gills are blood gills whose function is to eliminate carbon dioxide.

In the descriptions and keys of the present paper which refer to larvae, only mature or third instar larvae are considered, since the early instars are variable and afford less satisfactory and less constant characters for classification. In the aphidophagous forms, larvae of all ages are frequently found together in the same aphid colony.

The larvae, as Metcalf (1913b) has pointed out, fall into three natural groups: first, the aphidophagous forms, including several phytophagous species; second, the saprophytic forms, including the aquatic and semiaquatic rat-tailed maggots, which are omitted from this paper, the short-tailed slime dwellers, and the phytophagous bulb flies, *Merodon* and *Eumerus;* and, third, the aberrant *Microdon,* which is a scavenger in the nests of ants.

Aphidophagous Type.—The aphidophagous type is usually an anteri-

orly attenuated, twelve-segmented, subcylindrical larva. The cephalopharyngeal skeleton consists of the three typical sclerites of cyclorrhaphous larvae. The vertically-moving mandibular sclerites are supplemented by one or several pairs of small chitinized lateral hooks which work horizontally to seize the prey. Above the mouth opening is a pair of soft, fleshy antennal tubercles, each bearing apically a pair of minute processes.

The segments of the head are retractile, making their number difficult to distinguish. The short, rigid, heavily chitinized, anterior spiracular processes are generally considered by authors to be prothoracic, and the segment on which they are located appears to be the third. Behind this are nine segments exhibiting considerable secondary segmentation. Each segment bears twelve two-segmented, but simple spines, more or less elevated on rounded tubercles. On the anterior segments, they are in a nearly transverse row, but on the main body segments the various pairs occupy successively more posterior annulets, always in a definite position. The six *segmental spines* of each side have been named by Metcalf (1913b), beginning at the mid-dorsal line and progressing outward, as illustrated in Fig. 2: *median, dorsal, dorso-lateral, lateral* and two pairs of ventro-laterals, *posterior ventro-lateral,* and *anterior ventro-lateral.*

The integument is tough, but transparent and delicate in appearance. It is indistinctly divided into segments, each with four or five annulets. On the ventral surface are numerous lump-like expansions, and the whole surface, more or less, is brought into play as a creeping sole, but there are never any proleg-like structures as in the saprophytic forms.

Two anterior respiratory processes and a single posterior respiratory process are usually present. The posterior spiracles in this group are always three pairs of slits borne on the tip of two rigid tubes more or less completely fused into a posterior respiratory process which often protrudes considerably from the surface of the body. The surface on which the spiracles are borne has been designated the *posterior spiracular plate.* In addition to the spiracles, the posterior spiracular plate bears the scar of a former spiracle, a circular, rather weakly chitinized area, the *circular plate,* always located dorsad of the center of the posterior spiracular plate. Median to the circular plate there may be present a spine or ridge, elevated above the surface, the *dorsal spur,* and between the spiracles are, variously, nodules, setae, or frilled lamellae, but, in aphidophagous syrphids, never plumose hairs. These structures are referred to as *interspiracular nodules, interspiracular setae,* and *interspiracular lamellae.*

The rectal gills are structures which seem to afford, in different genera, interesting characters. They are rarely found extruded in aphidophagous forms, although the writer has seen some score of larvae of this type with the rectal gills fully everted in preserved larvae. No infallible method has

been devised to cause the living larvae to extrude their gills. These structures, however, can be readily examined *in situ* by simply splitting sagittally with a sharp razor blade a larva which has been killed in hot water and preserved for any length of time in 70 per cent alcohol. The rectum can be laid back from either half to expose the half of the paired gills on that side, directly laterad and caudad to the rectum. In all the aphidophagous genera examined, the gills were, on each side, a pair of simple finger-like processes joined at the base. Internally they terminate in a slender filament; when fully extruded they terminate in a simple closed, rounded end. They are represented *in situ* by Figs. 5, 7, 32, and 52; they are shown extruded in Fig. 48.

Saprophytic Type.—The rat-tailed larva, the short-tailed forms inhabiting filth or rotten wood, the phytophagous bulb flies which are actually immersed in a pocket of slime, the wood-boring form *Temnostoma,* and the scavenger *Volucella* are all modifications of the basic saprophytic type of larva characterized by a few rather constant characters. A *false head* is generally present; it consists of a broad anterior hood-like segment, as broad as or broader than the succeeding segments and separated from them by a slight constriction. The mouth parts are usually reduced and weak with the notable exception of the bulb flies, *Merodon* and *Eumerus,* in which the mandibular sclerites are greatly enlarged. The larvae of this group exhibit the longitudinal ridges on the floor of the pharynx which Keilin (1915) has pointed out as characteristic of saprophytic larvae. The external lateral mouth hooks of the aphidophagous larva are missing in this larva, but around the mouth opening is a pair of soft fleshy flaps. Over the mouth opening and continuous with the esophagous is an area of chitinous bars which appear as light brown striations; this is the *mouth-hood* of Metcalf (1913b).

The body is usually cylindrical and bears ventrally seven pairs of prolegs, each with a crown of recurved, heavy hooklets. In some genera the hooklets are missing *(Eumerus, Merodon);* in others, both the hooklets and prolegs *(Temnostoma)* are lacking. The segmental spines of this group may be single *(Temnostoma, Merodon)* but are most often double, triple, or multiple. There are frequently from one to four posterior fleshy projections covered with spines.

Probably the most typical feature of this type is the posterior spiracular plate. In the rat-tailed forms it is elevated on a long telescopic tube, rigid only for a short distance at the tip. In the short-tailed saprophytes the process bearing the posterior spiracular plates is rigid throughout its length. The posterior spiracles have elaborately looped, S-shaped or denticulated apertures. The openings in some genera are not confined to three pairs but have become subdivided into as high as twenty-five or thirty pairs of openings in *Temnostoma* and nine pairs in some

species of *Volucella.* The posterior spiracular plates are more completely fused in these forms than in the aphidophagous type and often form one simple oval plate. The circular plates are depressed and located near the center of the posterior spiracular plate. The spiracular plate is usually ornamented with four pairs of plumose hairs which are homologous with the interspiracular nodules.

The rectal gills in this group are often many-branched bilateral structures of a definite number of diverticula in each species (Gäbler, 1932; Alsterberg, 1934).

Microdon Type.—The *Microdon* type is one of the curiosities among dipterous larvae. The body form is strongly convex above, almost hemispherical, smoothly oval in outline from above and perfectly flat below. Prolegs are wanting, and the larvae creep with a wave-like motion of the ventral sole. Around the margin is a fringe of fleshy hair-like processes which Metcalf (1913b) suggests may be the migrated homologues of the segmental spines. No segments of any sort are visible. The tough, horny dorsum is ornamented with a reticulate pattern of ridges, papillae, or setae and is usually divided longitudinally into three sections by shallow grooves.

The anterior spiracular processes appear to be missing. The posterior respiratory process is a rigid, apically bifid structure which is very unusual. The circular plates are located in the median notch between the posterior spiracular plates, if the latter can be said to be present at all. The area enclosing the spiracles is swollen and dark, occupying not only the tip but also a short portion of the sides of the process. A complex system of many-branched lobules is visible in this region, but the actual openings of the spiracles are not apparent.

Puparium

The puparium in the aphidophagous forms is a typical cyclorrhaphous puparium formed by induration of the integument of the third instar larva. The body shortens and rounds up, producing a stream-lined or tear-drop form whose proportions vary characteristically in the different genera. The integumental vestiture and processes of the larva remain on the puparium but are shrivelled and distorted. The anterior respiratory processes of the larva, always small, tend to become almost invisible with the contraction of the integument and are not functional in any case. The posterior respiratory process is morphologically similar but often more highly pigmented than that of the larva. The pupal respiratory horns do not appear externally in the puparia of this type. In *Melanostoma mellinum,* according to Metcalf (1916), they can be seen through the unusually transparent integument, as minute specks on the anterior

dorsum of the puparium. But in the single specimen in the writer's possession, the minute respiratory horns actually protrude through the surface of the integument and are visible in profile as tiny nodules. Emergence from the puparium in all Syrphidae occurs through a circular opening produced when the anterior portion breaks open along certain definite abscission lines. In late puparia, the zones of weakening are so well developed that the cap, or *operculum,* can be readily removed by the touch of a needle. The operculum is convex, circular, and subdivided into a dorsal, crescentic piece and a ventral, scallop shell-shaped piece. These break apart from one another and swing outward like doors to permit emergence and are usually left attached at the upper and lower margins of the opening.

In saprophytic forms the puparium is similarly formed from the indurated, inflated, larval integument, but its shape is more fusiform than that of the puparium of the aphidophagous type and is often angular anteriorly. It bears external pupal respiratory horns which are thrust up from the pupa through the upper or crescentic plate of the operculum, rupturing the integument. These do not appear for some time after pupariation, but their site can always be detected by a pair of swollen pad-like areas on the dorsum, which are obvious not only in the early puparium but even in the mature larva. The pupal respiratory horns bear numerous minute apertures.

In the *Microdon* type the shape of the larva, which is relatively rigid, changes little, but becomes much hardened and horny. Pupal horns similar to those in the saprophytic type sprout from the operculum.

FOOD HABITS AND PUPARIATION

Although this paper is primarily taxonomic, a consideration of the food habits of the larvae should not be disregarded. They often afford indications of the identity of the larva or puparium found. For this reason a detailed account of the known food habits has been given for every species.

An interesting review of the literature on the food habits of the larvae of Syrphidae is given by Metcalf (1913b) in "The Syrphidae of Ohio."

Thirteen of the twenty-five genera discussed in this paper are aphidophagous or feed on related Homoptera. These are included in the first fourteen genera listed; the genus *Mesogramma* which is included in this list is exceptional in that the only species whose habits are definitely known is phytophagous. The predaceous syrphids crawl blindly among their host aphids lashing about with the anterior segments until an aphid is found, when the aphid is punctured by the sharp mouth hooks, raised into the air by all but very young syrphids, and drained of its body juices.

The larvae feed voraciously, one individual consuming as high as 530 aphids during its short larval life according to Curran (1920). Since certain of the aphidophagous species are very abundant, they hold in check many a severe aphid infestation by their ravages in colonies of aphids. Many aphid colonies are entirely wiped out and syrphid larvae are not uncommonly encountered moving along twigs with a looping motion in search of food where no aphids are present. The beneficial effect of the activities of the aphidophagous species of the family probably far outweighs the damage done by the harmful members of the family.

The larvae of the genera *Melanostoma* and *Platychirus* are seldom seen. They feed at night and rest in protected crevices by day, showing strong preference for extremely moist situations. The larvae of the genus *Didea* appear to be confined largely to one-host aphids, and those of *Pipiza* are generally found in colonies of woolly aphids.

The larvae of *Mesogramma polita* feed on the pollen and scarify the tissues of corn. They, too, appear to lie quiescent during the day and feed chiefly at night.

The larvae of the genera *Merodon* and *Eumerus* are the most destructive forms of the family in the United States. They attack healthy bulbs, scraping out the interior of the bulb and causing it to decay and die. They are not common enough in Illinois to be pests of great importance.

The larvae of *Syritta* and *Tropidia* live primarily in manure; those of *Xylota, Brachypalpus,* and *Temnostoma* are found in rotting, moist wood. *Xylota, Brachyopa,* and *Ceria* are recorded from the sap of tree wounds and putrifying pockets of water in tree cavities.

The larvae of *Volucella* are recorded in this region as scavengers in the nests of *Bombus* where they eat dead and dying pupae. The bizarre mollusc-like larvae of *Microdon* are found in the nests of ants and were shown by Donisthorpe in 1911 to feed on the pellets ejected by the ants from their infrabuccal pockets.

Pupariation occurs in many of the aphidophagous forms on the plant on which its host aphids were found. In many cases, the larva crawls to the ground and there pupariates under trash.

The larvae of *Mesogramma polita* always pupariate on the corn plant.

The larvae of the bulb flies leave the wet interior of the bulb and find a drier place for pupariation. This may be on the foliage of the plant, or may be just below the soil surface.

The saprophytic larvae seek a comparatively dry and protected place, under bark, in the drier parts of manure or rotting wood, usually near the surface.

The larvae of *Volucella* and *Microdon* pupariate usually near the entrance of the nests of their hosts.

EVIDENCE OF GENERIC RELATIONSHIPS AFFORDED BY THE LARVAE

The arrangement of the genera which is used in this paper does not attempt to show an absolute phylogenetic sequence. The genera have, however, been listed with some regard to bringing together those closely related in form or habit.

Williston stated in his classic "Synopsis of North American Syrphidae" that, "a classification drawn from the earlier [larval] characters can rarely supersede that founded upon the mature ones, though it may materially modify it." On the other hand, it seems possible to the writer, that the greater number and complexity of characters of the adult Syrphidae may sometimes serve to confuse the picture and cause the taxonomist of adult forms only to split groups unjustifiably or to unite forms which merit different generic status. The soundness of adult classification is corroborated and enforced when it is found that a unity exists between the larvae as well as between the adults of a given genus.

The larvae and puparia of the Syrphidae exhibit as much variety of form and life habits, perhaps, as can be found in any one family of the Diptera. Within any one genus, however, with a few exceptions, the species are remarkably uniform, not only in structure, but in life habits.

The close structural relationship of the typically aphidophagous genera and the typically saprophytic genera to one another has been pointed out previously. Within the aphidophagous group is an interesting sub-group. The genera *Sphaerophoria, Allograpta, Melanostoma, Platychirus,* and *Mesogramma* are all smooth, delicate-skinned larvae of closely similar habitus. In addition, their food habits are annectant. *Sphaerophoria* and *Allograpta* are primarily aphidophagous, although Davidson (1922) records that the early stages of *Allograpta obliqua* may live for the first few days on plant food. *Melanostoma* and *Platychirus* larvae are often found in situations where no aphids, or few, are present, and Curran has observed (Davidson, 1922) that the larvae of *Melanostoma obscurum* consumed both aphids and decomposing chick-weed and that they were more successful on the latter diet. From this facultative aphidophagous habit it is but a step to the truly phytophagous habit of *Mesogramma polita.*

The American species of the genus *Metasyrphus* have been separated from *Syrphus* by Dr. C. L. Fluke (1933); the larvae of the two genera are actually very distinct although their life habits are much the same. But in the same genus with the adults of the sub-cylindrical *Metasyrphus wiedemanni* larvae, he placed the adults of the very flattened, fringed larvae of the *"Metasyrphus" emarginatus* group and of the less flattened larvae of *Epistrophe.* In a later paper he placed the latter group in the

genus *Epistrophe*. The evidence from the known larvae would seem to show that *Epistrophe* is a unified group quite distinct from *Metasyrphus,* as Fluke has definitely shown in his taxonomic studies of the adults, and that his removal of the larvae of *Metasyrphus* is also correct. The characters of the larvae also indicate that the *emarginatus* group which Dr. Fluke placed with *Metasyrphus* does not belong there. Dr. Fluke has communicated personally to the writer that it was included in this genus with considerable doubt but that the adults are more closely related to *Metasyrphus* than to *Epistrophe*. Furthermore, the species of the *emarginatus* group obviously, on the basis of larval characters, do not belong in the genus *Xanthogramma* in which they are originally described. *Xanthogramma flavipes,* according to Fluke, is the only North American species which comes within Schiner's original characterization and its larva is strikingly different from those of the *emarginatus* group but similar to a Czechoslovakian species of *Xanthogramma,* illustrated by Vimmer (1933). The characters of the larvae thus indicate that in this closely related group of genera, *Syrphus, Metasyrphus, Epistrophe,* and the *emarginatus* group are each distinct and, in the larvae, well-defined genera.

The adults of the genera *Melanostoma* and *Platychirus* are so closely related that it is sometimes exceedingly difficult to place the females even in the correct genus with any certainty. The same similarity exists between the larvae, but neither Dr. Fluke nor the writer, apparently the only two who have attempted to separate the larvae of these genera, has had sufficient material to say whether they may or may not be indistinguishable. If the larvae, after careful study, were indistinguishable, it would seem that the separation of the two genera may be doubtfully valid.

PARASITES

In the course of rearing materials for this study a number of parasites of Syrphidae were reared as well. A list of the known parasitic Hymenoptera and the syrphids from which they have been reared is appended at the end of this paper. Their significance is not small when it is considered that those which are not hyper-parasites limit the usefulness of beneficial syrphid larvae.

The parasites fall into three hymenopterous families, Ichneumonidae, Chalcididae, and Cynipidae. The ichneumons reared were the following species: *Diplazon laetatorius* (Fab.), a preponderantly numerous species, *Diplazon scutellaris* (Cress.), *Syrphoctonus agilis* (Cress.), *Syrphoctonus pleuralis* (Cress.), and *Zamicrotoridea syrphicola* (Ashm.). The chalcids included four species: *Bothriothorax peculiaris* Howard, *Eupteromalus dubius* (Ashm.), *Pachyneuron allograptae* Ashm., and *Syrphophagus*

smithi Kamal. The cynipids were the species *Callaspidia provancheri* Ashm. and *Aspicera* sp.

Of the ichneumons, the extremely common *Diplazon laetatorius* is probably the most important. As a parasite, it lays its eggs in the larva of the host or in the egg on plants, and the adult female destroys many other eggs of syrphids by feeding on them. Kamal (1926a) describes observing a female *D. laetatorius* drill a hole in an egg with her ovipositor and then suck the contents dry. This predaceous habit has been observed also by the writer. When the egg of the parasite is laid in the egg of the host, the larva does not hatch until after the host larva has hatched. In either case the adult emerges from the host puparium through a ragged hole bitten from the anterior end. One parasite only emerges from each host. The species of *Syrphoctonus,* according to Kamal, oviposit in the larva only.

The chalcids are multiple parasites, and from five to thirty individuals emerge from one host through a small round emergence hole usually at the side and ventrad. The species of the genus *Bothriothorax* emerge from both host larvae and host puparia in which they cause a characteristic lumpy, cobblestone-like deformation of the body surface. The numerous oval swellings of the surface are indications of internal cavities occupied by the developing parasites. According to Kamal, *Pachyneuron allograptae* and the species of *Conostigmus* are pupal parasites, laying their eggs on the surface of freshly formed puparia.

The cynipids emerge from the puparium of the host, one to a host. Which stage of the host is actually attacked is not known to the writer.

A parasitized puparium can be detected within a few hours after pupariation; the integument becomes unusually dark with a brassy or slightly greasy sheen. The puparium often fails to round up properly and is notably more slender than a normal one. If the investigator is still in doubt, it is only necessary to await the normal emergence of the syrphid which takes an average of seven days in the summer. If the fly does not emerge on schedule it is usually parasitized, for the parasites always take longer for their development than the syrphid. The ichneumons emerge in from ten days to two weeks, the chalcids in about the same length of time, and the cynipids take from twenty-four to thirty-nine days for their emergence after the pupation of the host.

OTHER LARVAE RESEMBLING SYRPHIDAE

The collector of syrphid larvae inevitably comes across other aphid predators, some of which resemble Syrphidae to such an extent that they may at first be mistaken for syrphids. In the first instar many species of syrphids have non-contiguous posterior spiracular plates, and since the

predatory dipterous maggots of other families when mature are no larger than first instar syrphids, this confusion is not an unnatural mistake.

Very common among aphids attacking cabbage and kohlrabi is *Aphidoletes meridionalis* Felt, a bright orange or pinkish cecidomyiid maggot which never attains a length of more than 2 mm. Its conspicuous third instar resembles, at first acquaintance, a very young syrphid. The life history and immature stages of *Aphidoletes meridionalis* have been described in detail by Davis (1916).

A predaceous agromyzid larva, *Leucopis americana* Malloch was encountered among colonies of the corn leaf aphid and the leaf-curling aphid of elm, *Georgiaphis ulmi* (Wilson). Malloch (1921) records it from several other aphids, on black locust, spirea, apple, and from *Aphis rumicis* L. It is a broadly wedge-shaped, white or greyish maggot slightly larger than *Aphidoletes,* averaging from 2.5 to 3 mm. in length when mature. Its short posterior respiratory processes diverge in two prominent cornicles from the posterior angles of the wedge-like body.

On the flower heads of *Verbasina,* a coarse fall composite with wing-like ridges along its stem, was found a much larger larva, of 10 to 12 mm., beautifully patterned in tones of green and brown. Its concealing coloration among the folded sepals of the flower head made it very difficult to detect, as is true of many syrphids. The plants were infested with *Macrosiphum ambrosiae* Thomas. The larva, however, is not a syrphid but *Cyaniris ladon* Cramer (= *Cyaniris pseudargiolus* Boisduval and Le Conte). On removal from the plant, although the larva is legless a small black chitinized head is apparent. The family Lycaenidae, to which this species belongs, is known to include several other predaceous species.

TAXONOMY

Glossary

The following list of terms is given to assist the student of Syrphidae in the use of the keys. The definitions given are not intended to be comprehensive but only to clarify the terms as they are used in this paper. In general the writer has attempted as much as possible to avoid technical terminology, but it is necessary to employ expressions which indicate, as nearly as possible, the position and nature of the structure involved. Those concerning the posterior respiratory process are confusing because of their similarity but have been chosen with the intention of indicating, in each case, a distinct structure or part of a structure.

Carina: The ridge on which the posterior spiracles are sometimes elevated, or a dorsal ridge of the puparium.

Circular plate: A relatively weakly chitinized, refractive area on the dorsal inner

sector of the posterior spiracular plate or, in saprophytic forms, a sunken area located at or just above the center of the posterior spiracular plate, the inner stigmatic scar of Snodgrass.

Dorsal spur: A sharply pointed spine or a ridge-like elevation of the posterior spiracular plate dorsad and mesad to the circular plate.

False head: A broad, globose or hood-like anterior segment or segments with a visible constriction behind them.

Integumental vestiture, integumental setae: The numerous, minute spines or hairs which may cover the epidermis, not including the segmental spines.

Interspiracular nodule, interspiracular seta, interspiracular lamella: A rounded or roughened protuberence, hair, or lamella situated on the posterior spiracular plate in the angles formed by the spiracles.

Lateral thorns: Heavily chitinized, prominent, curved hooks on the lateral margins of the dorsum of the false head.

Operculum: The convex cap or anterior end of the puparium which splits off in two pieces when the fly emerges.

Posterior respiratory process: The entire posterior respiratory organ, composed of two more or less completely fused tubes.

Posterior spiracles: The apertures or breathing openings on each posterior spiracular plate; they may be slit-like or elaborately looped and convoluted.

Posterior spiracular plate: The flattened, or slightly rounded tip of each tube which bears the posterior spiracles.

Pupal respiratory horns: Horn-like processes which grow up from the pupa and pierce the upper portion of the operculum in saprophytic forms; they possess numerous respiratory openings.

Rectal gills: Paired, eversible, finger-like sacs which may be extruded from the anal opening.

Segmental spines: Twelve major bristles on each segment, approximately in a transverse row in definite positions; the method of designating these spines is discussed in the section on the larva.

Spiracles I, II, III: The posterior spiracles usually occur in three pairs; the dorsal pair is designated I, the median, II, and the most ventral, III.

Key to the Known Genera

Larvae

Larvae tapering, elongate, of typical maggot-like form, variously wrinkled but without any distinct fleshy projections other than wrinkles (Figs. 1, 40) 1

Larvae various, flattened, cylindrical or hemispherical, with or without fleshy projections of the body, but not of typical maggot-like form (Figs. 50, 60, 72, 78, 84, 105) 9

1. Smooth or moderately wrinkled, sleek, glistening-skinned, usually unicolorous larvae devoid of any integumental vestiture (Fig. 1) 2

Noticeably wrinkled larvae, usually with a well developed color pattern of diagonal stripes, often with integumental vestiture (Figs. 25, 29, 40) 5

2. Posterior respiratory process, nearly twice or more than twice as long as height at tip; lettuce-green, cigar-shaped larvae (Figs. 3, 8) 3

Posterior respiratory process almost sessile, variously colored but very transparent larvae, the posterior segments usually conspicuously broader and flatter than the rest (Figs. 10, 12) 4

3. Tips of posterior respiratory process roughened when viewed from above, the spiracles elevated on carinae and separated by spur-like elevations; spiracles I and III parallel or almost opposite one another (Figs. 8, 9) .... *Allograpta*
   Tips of posterior respiratory process smooth and rounded when viewed from above; the spiracles not elevated on carinae nor separated by perceptible spur-like elevations; spiracles I and III converging at an angle (Figs. 3, 4) .... *Sphaerophoria*
4. Posterior spiracle I conspicuously shorter than II and III and widely separated from II and III (Figs. 12, 14, 17) .... *Mesogramma*
   Posterior spiracles all of about equal length and in normal positions (Figs. 20, 21) .... *Melanostoma, Platychirus*
5. Posterior respiratory process shorter than its height but not sessile; dorsal spur present or absent (Figs. 24, 27, 90) 6
   Posterior respiratory process longer than high or equal to height of tube at tip; posterior spiracular plate with well-developed dorsal spur or ridge (Figs. 31, 40, 43) 8
6. Sharp dorsal spur on posterior spiracular plate (Figs. 23, 27) .... *Eupeodes*
   No sharp dorsal spur on posterior spiracular plate 7
7. Posterior spiracular plate slanting obliquely ventro-anteriad, so that only the two upper pairs of spiracles are visible usually; very prominent, large segmental spines on high fleshy tubercles; smaller larvae (10 mm.) (Figs. 85, 87, 88, 89, 90, 93) .... *Baccha*
   Posterior spiracular plate normal in position, all spiracles visible at once when viewed from end; larger larvae, 14-16 mm. (Fig. 24) .... *Lasiophthicus*
8. Except for inconspicuous segmental spines, no integumental vestiture; posterior spiracular plates smoothly rounded with no high carinae, dorsal spur a blunt ridge; robust, broader larvae (Figs. 29, 31) .... *Syrphus*
   Integument covered with small sharp spines; posterior spiracular plates angular, with high carinae; dorsal spur a short sharp spine (Figs. 40, 45) .... *Metasyrphus*
9. Larvae with lateral fleshy projections, which may be small and caudal in position (*Merodon* and *Volucella,* in part) (Figs. 60, 69, 78, 109, 113, 117) 10
   Larvae without lateral fleshy projections or, if with a fringe of minute fleshy hairs, hemispherical in shape (Figs. 96, 105, 143) 25
10. Numerous lateral fleshy projections around entire body margin (Figs. 50, 60, 78) 11
    One or more pairs of lateral fleshy projections on posterior segments only (Figs. 69, 113, 117) 17
11. Lateral fleshy projections on sides, but none on dorsum (Figs. 50, 60) 12
    Lateral fleshy projections on sides continuous over dorsum in conspicuous pointed processes (Figs. 78, 84) 13
12. Body broadly ovate; lateral fleshy serrations flattened, on a single plane, posterior spiracular plates bear rugose interspiracular nodules (Figs. 50, 54) .... *"Metasyrphus" emarginatus* group
    Body elongate oblong; lateral fleshy serrations plump, on three slightly different levels, posterior spiracular plates bear short bristles on papillae instead of nodules (Figs. 60, 64) .... *Epistrophe*
13. Large larvae (15 mm.), covered with black spinules, posterior spiracular plates almost sessile and ornamented with upright, frilled lamellae (Figs. 83, 84) .... *Didea*

Smaller larvae (6-10 mm.), usually bare or with only pale, microscopic spinules, posterior respiratory process longer and without frilled lamellae (Figs. 79, 140) 14

14. Posterior respiratory process more than three times as long as height at tip (Figs. 140, 146) 15

Posterior respiratory process at most three times its height at tip (Figs. 74, 75) 16

15. Main body segments with three dorsal transverse rows of small, fleshy, bristle-like projections in addition to eight or ten larger dorsal tubercles bearing triple, segmental bristles; posterior respiratory process four times as long as wide (Fig. 140) .... *Brachyopa*

No small fleshy bristle-like projections on dorsum, main body segments bearing sixteen tubercles; posterior respiratory process six times as long as wide (Fig. 146) .... *Cerioides signifera*

16. Cylindrical larvae with high transverse rows of rounded tubercles bearing large spines; posterior respiratory process without dorsal spur; integument covered with very short, fine setae (Figs. 85, 87, 88) .... *Baccha*

Broad, slightly flattened larvae without prominent rounded tubercles, but with prominent pointed processes; posterior respiratory process with dorsal spur; integument papillose; larvae about 7 mm. long (Figs. 75, 78, 79) .... *Paragus*

17. Posterior fleshy projections three pairs of long tapering tentacle-like structures, at least three or four times the length of the posterior respiratory process (Fig. 142) .... *Volucella* (in part)

Posterior fleshy projections subequal or but slightly longer than the posterior respiratory process 18

18. No distinguishable false head; no ventral prolegs bearing hooklets, posterior fleshy projections very small (Figs. 69, 109, 113) 19

A false head present; ventral prolegs, each bearing a crown of hooklets (Figs. 103, 134) 21

19. Posterior respiratory process shorter than wide, large larvae (13-15 mm.) with one pair of very small fleshy lateral projections just ventral to the posterior respiratory process (Fig. 109) .... *Merodon*

Posterior respiratory process subequal to or longer than wide (Figs. 78, 79) 20

20. Posterior spiracles simple, straight slits on high carinae, separated by strong, simple interspiracular bristles (Fig. 70) .... *Pipiza*

Posterior spiracles contorted, not raised from the surface, each posterior spiracular plate with four groups of palmate hairs (Fig. 122) ...... *Eumerus*

21. No stout hooks on false head (Fig. 117) 22

One or more pairs of stout polished hooks on false head (Figs. 103, 134, 136) 23

22. Small larvae, under 10 mm. .... *Syritta*

Large larvae, 20 mm. .... *Volucella* (in part)

23. A single pair of large lateral hooks on false head and numerous lesser hooklets (Fig. 130) .... *Brachypalpus frontosus*

Two pairs of large lateral hooks on false head and numerous lesser hooklets 24

24. The two large lateral hooks of each side united at base (Figs. 99, 100, 103) .... *Xylota*

The two large lateral hooks of each side separated by more than the length of one of them (Fig. 138) .... *Tropidia*

The two large lateral hooks on the same basal plate and separated by less than their diameter (Fig. 131) .... *Brachypalpus rileyi*

25. Larvae hemispherical, mollusc-like, usually with a fringe of hairs around the margin (Fig. 143) .... *Microdon*

Larvae cylindrical (Figs. 94, 96, 105) 26

26. Larvae with two heavy-toothed thoracic rakes anteriorly; posterior spiracular plate ornamented with marginal teeth and feathery palmate hairs Figs. 105, 107) .... *Temnostoma*

Larvae with no thoracic rakes, posterior spiracular plate smoothly rounded and without ornamentation (Figs. 94, 96) 27

27. Larva with posterior spiracular tubes united at tip into a smooth oval plate; spiracles without carinae and elaborately contorted in four or five distinct loops; interspiracular nodules extremely minute (Fig. 97) .... *Xanthogramma flavipes*

Larva with posterior spiracular tubes united at tip in crudely 8-shaped outline; slightly sinuous spiracles on prominent carinae; interspiracular nodules large, raised, wedge-shaped areas (Fig. 95) .... *Chrystoxum pubescens*

Puparia

Puparium with no external evidence of pupal respiratory horns on upper plate of operculum; posterior spiracules of each side three straight simple slits except in *Xanthogramma flavipes* and *Metasyrphus nitens* (Figs. 18, 28, 37, 42, 97) 1

Puparium with either pupal respiratory horns or with two pad-like swellings on the upper plate of the operculum; the small persisting anterior respiratory process of the larval stage is found at the ventral anterior margin of the operculum and should not be mistaken for the pupal respiratory horns; posterior spiracles elaborately looped or denticulate slits, or foliate, except in *Melanostoma;* sometimes more than three (Figs. 108, 111, 112, 129, 141, 145) 17

1. Posterior spiracles elaborately contorted (Figs. 42, 97) 2

Posterior spiracles three pairs of simple slits, more or less straight (Figs. 6, 45, 83) 3

2. Tip of posterior respiratory process completely fused into one oval spiracular plate, spiracles not raised above the surface, body of puparium a short cylinder (Fig. 97) .... *Xanthogramma flavipes*

Tip of posterior respiratory process separated by a median incision into two spiracular plates, spiracles raised on carinae, body of puparium of typical tear-drop shape (Fig. 42) .... *Metasyrphus nitens*

3. Posterior spiracular plates bearing simple, sometimes small, bristles between the spiracles; usually narrow, elongate puparia with roughly corrugated margins (Figs. 65, 67, 68, 71) 4

Posterior spiracular plates bearing interspiracular nodules or lamellae, or apparently no interspiracular structures, but never bristles (Fig. 47) 5

4. Puparium bulbous anteriorly and dorso-ventrally, flattened posteriorly, narrow, lateral margins irregularly corrugated, often marked with black; interspiracular bristles weak (Figs. 64, 65, 68) .... *Epistrophe*

Puparium convex but not strongly bulbous anteriorly, usually roughened, rugose posteriorly; interspiracular bristles strong (Figs. 67, 70)..... *Pipiza*

5. Puparium with shrivelled tags of larval fleshy projections, especially on the posterior segments or marked spike-like projections (Figs. 51, 77, 86, 91). 6

Puparium curving cleanly down to posterior respiratory process without any obvious tags, though sometimes strongly wrinkled in the posterior region (Figs. 16, 28, 37).. 9

6. Puparium dorso-ventrally flattened on posterior third, strongly arched ventrally, with fleshy tags around entire margin, usually distinctly marked with black (Fig. 51)....................*"Metasyrphus" emarginatus* group

Puparium compact or slender but not distinctly flattened posteriorly; fleshy tags over entire back as well as around margins (Figs. 77, 86).......... 7

7. Puparium large (10 mm.), golden brown, covered with black bristles, spotted with four longitudinal rows of black, spined papillae; posterior spiracular plates with frilled interspiracular lamellae (Fig. 83)................. *Didea*

Puparium small (5-6 mm.), shrivelled spines usually unicolorous with rest of integument, no frilled interspiracular lamellae (Fig. 77)............. 8

8. Posterior respiratory process approximately shorter than high, no dorsal spur on posterior spiracular plate (Figs. 88, 93).................... *Baccha*

Posterior respiratory process longer than high, well developed; sharp dorsal spur on posterior spiracular plate; very small, plumply rounded puparia (Figs. 74, 77)... *Paragus*

9. Slender, smooth, clavate puparia, green, straw-colored or light brown but often transparent, revealing through the integument in the late stages the adult abdominal pattern; the anal segment usually broadened into a flat sole; dorsal spur absent; posterior spiracles usually in a dark, roughly triangular field, or heavily outlined in black (Figs. 9, 17, 21)........... 10

Roundly inflated, rougher puparia, usually strongly wrinkled about the posterior segments; dorsal spur present except in *Lasiophthicus;* posterior spiracles not in a dark triangular field (Figs. 28, 37).................. 13

10. Posterior respiratory process nearly twice as long as height at tip (Fig. 8) 11

Posterior respiratory process almost sessile (Fig. 16).................... 12

11. Tip of posterior respiratory process roughened when viewed from above; posterior spiracles elevated on carinae and separated by spur-like elevations, spiracles I and III parallel or almost opposite one another (Figs. 8, 9).. *Allograpta*

Tip of posterior spiracular process smooth and rounded when viewed from above, spiracles not elevated on carinae nor separated by perceptible spur-like elevations, spiracles I and III converging at an angle (Figs. 3, 4, 6)... *Sphaerophoria*

12. Posterior spiracle I conspicuously shorter than II and III and widely separated from them (Fig. 12).................................. *Mesogramma*

Posterior spiracles all of about equal length and in normal positions (Fig. 20)... *Platychirus*

13. No dorsal spur on the posterior spiracular plate, large robust puparia (7-9 mm.) with the posterior end characteristically turned down below the ventral surface (Fig. 28)................................ *Lasiophthicus*

A dorsal spur present on the posterior spiracular plate, puparia usually smaller than above, some quite robust, but posterior end usually not turned down below the ventral surface (except *Eupeodes*) (Fig. 37).... 14

14. Posterior respiratory process shorter than its height, posterior spiracles II and III nearly parallel to the median axis of the larva and all three approximately parallel to one another (Figs. 23, 27)................*Eupeodes*
Posterior respiratory process as long as or longer than its height, posterior spiracles II and III rarely nearly parallel to the median axis of the larva, but when this occurs, spiracle I is always distinctly convergent with II and III (Figs. 36, 45).. 15
15. No integumental vestiture, posterior spiracular plates smoothly rounded with moderate or no carinae; plump, inflated puparia (Figs. 33, 36, 94, 95).... 16
Integument covered with spinules, posterior spiracular plates angular with high carinae, dorsal spur a sharp spine; longer, oblong puparia (Figs. 40, 43)...*Metasyrphus*
16. Dorsal spur a blunt ridge; interspiracular nodules usually rounded or oval projections (Fig. 36)..*Syrphus*
Dorsal spur a tube-like structure surrounding the circular plate; interspiracular nodules granular raised wedges (Fig. 95)....*Chrysotoxum pubescens*
17. Puparium slender, clavate, smooth and devoid of vestiture; pupal respiratory horns minute, posterior spiracles straight and simple (Fig. 19)..*Melanostoma*
Puparium not as above... 18
18. Puparium with flat, nearly circular operculum and two heavy-toothed thoracic rakes at ventral edge of operculum (Fig. 108)...........*Temnostoma*
Puparium with convex operculum and no thoracic rakes (Figs. 111, 137, 141)... 19
19. Puparium with one or more stout polished curved hooks on each side just below the ventral edge of the operculum (Figs. 99, 101)................ 20
Puparium with no stout curved hooks at the ventral edge of the operculum (Figs. 123, 126)... 22
20. A single stout hook on each side (Fig. 130)...........*Brachypalpus frontosus*
Two stout hooks on each side (Figs. 99, 131, 141)....................... 21
21. The two stout hooks of each side joined at base (Figs. 99, 100).........*Xylota*
The two stout hooks of each side separated by more than the length of one (Fig. 141)..*Tropidia*
The two stout hooks on the same basal plate and separated by less than their diameter (Fig. 131).............................*Brachypalpus rileyi*
22. Many shrivelled projections of tubercles over whole body, some long and hair-like (Figs. 77, 140, 146)...................................... 23
Shrivelled fleshy projections only at posterior end or ventral margin of body (Figs. 111, 123, 143).. 24
23. Posterior respiratory process at least six times as long as high at tip (Fig. 146)...*Cerioides signifera*
Posterior respiratory process not more than four times as long as high at tip (Fig. 140)..*Brachyopa*
24. Puparium hemispherical, or oval and strongly arched above, flat below, with a fringe around the ventral margin (Fig. 143)..............*Microdon*
Puparium cylindrical or fusiform (Figs. 96, 98, 111, 123).................. 25
25. Puparium large (13 mm.), with posterior respiratory process short, broad and stump-like, about as long as wide except in *Volucella nigra* (Figs. 111, 142)... 26
Puparium small, not over 8 mm. long, with posterior respiratory process considerably longer than broad (Figs. 123, 126)...................... 27

26. A single pair of short papilla-like fleshy projections near the posterior respiratory process; the two posterior spiracular plates fused into one transverse oval plate (Figs. 111, 112) .... *Merodon*
Three pairs of fleshy projections near the posterior respiratory process, in some species very short; in others longer than the posterior respiratory process; the two posterior spiracular plates usually more or less divided by dorsal and ventral grooves (Fig. 142) .... *Volucella*
27. Pupal thoracic horn capitate, three pairs of minute posterior fleshy projections (Figs. 121, 126) .... *Syritta*
Pupal thoracic horn tapering, four pairs of minute posterior fleshy projections (Figs. 120, 123) .... *Eumerus*

DESCRIPTIONS AND KEYS TO SPECIES

In general, the descriptions of larvae apply to mature or third instar larvae and to living, not preserved colors.

ALLOGRAPTA Osten Sacken

To the genus *Allograpta* and its closest relative, *Sphaerophoria,* belong two of the most common and most important of aphid predators, *Allograpta obliqua* Say and *Sphaerophoria cylindrica* Say. The larvae of both are so similar in general appearance and habits that it is difficult to distinguish even the genus without careful inspection. Both occur abundantly throughout the aphid season and may be found among aphids of almost any species.

Allograpta obliqua Say

The larva and puparium have been fully described and figured by Metcalf (1912a, 1913b, 1916), by Jones (1922), by Campbell and Davidson (1924), and by Fluke (1929), as well as by other earlier workers in a more general fashion.

Description of the Larva.—Length, 9-11 mm., width, 2.5 mm., height, 2.5 mm. The larva is smooth-skinned, cylindrical, and leaf-green with two slender longitudinal stripes of pale green or white close to the midline on either side of the dorsal blood vessel. The segmental spines are pale and inconspicuous. There is no integumental vestiture; the larva is transversely wrinkled, but the ridges' between the wrinkles are not prominent and, to the naked eye, it appears smooth and glossy. The posterior respiratory process is longer than the combined width of the tubes and is pale strawy tan, but the carinae may be outlined in deep brown or black. A simple two-branched pair of rectal gills sometimes protrudes from anal opening.

Recognition Characters.—1. Tip of the posterior respiratory process

in profile irregular, posterior spiracles raised on carinae and large, protruding interspiracular nodules (Fig. 8). 2. Posterior spiracles I and III nearly in one line drawn through them diagonally across the plate (Fig. 9). 3. Posterior respiratory process at least 0.5 mm. long, and the two component tubes divergent at the tip. 4. The tubes of the posterior respiratory process divergent at their tip (Fig. 8).

Puparium.—Length, 5.5 mm., width, 2.5 mm., height, 2.3 mm. The puparium of *Allograpta obliqua* has an elongate tear-drop shape, somewhat cylindrical medially. The surface becomes inflated and loses all trace of wrinkles. Clear light green at first, it usually changes to a clear rich brown. Some puparia remain green throughout the puparial period. Late in the puparial period, the reddish eyes and dark diagonal abdominal stripes of the imago can sometimes be readily seen through the transparent integument. The characteristics of the posterior respiratory process are the same as those of the larva.

Food Habits.—The larvae of this species have been taken among colonies of the following aphids: *Aphis gossypii* Glover on muskmelons and cucumbers, *Rhopalosiphum pseudo-brassicae* (Davis) on turnips, *Amphorophora cosmopolitana* Mason on wild lettuce, *Myzocallis alhambra* Davidson on burr and white oak, *Macrosiphum sanborni* Gillette on chrysanthemum, *Aphis viburnicola* Gillette on viburnum, *Aphis rumicis* Linn. on curly dock, *Aphis oestlundi* Gillette on evening primrose and *Myzus persicae* (Sulzer) and *Brevicoryne brassicae* (Linn.) on cabbage, kohlrabi, and broccoli. Curran (1920) lists in addition *Aphis pomi* DeGeer, the green apple aphid, *Aphis cardui* Linn., the thistle aphid, and *Myzus cerasi* (Fabr.), the black cherry aphid.

SPHAEROPHORIA St. Fargeau and Serville

The larvae of this genus, like those of *Allograpta,* are common and valuable enemies of aphids. They exceed in numbers any other species of syrphid in this region, except *Mesogramma marginata,* whose larval food habits are unknown. Since, according to Curran (1920), the larvae of this species also consume more aphids per individual than those of any other species, this species may be said to be the most beneficial syrphid in Illinois.

KEY TO SPECIES OF SPHAEROPHORIA

Smaller larvae, averaging 10 mm., posterior respiratory process 0.5 mm. in length, the tip fairly smooth with small interspiracular nodules....*cylindrica*

Larger larvae, averaging 11 mm., posterior respiratory process much shorter than that of *cylindrica,* 0.25 mm. to 0.45 mm. and with a very smooth tip...*robusta*

Sphaerophoria cylindrica (Say)

The larva and puparium of this species are described in detail and figured by Metcalf in 1912. In 1913 and 1916, briefer descriptions are given by the same author. The posterior spiracular plate is figured by Fluke (1929), who reports this species less common in Wisconsin than *Sphaerophoria robusta (scripta).*

Description of the Larva (Fig. 1).—Length, 10 mm., width, 2.5 mm., height, 2.5 mm. It is a smooth, green larva of the same size, color, and habits as *Allograpta* and can be distinguished from it only by the characteristics of the posterior respiratory process given below.

Recognition Characters.—1. Tip of the posterior respiratory process in profile smoothly rounded and shallowly notched; posterior spiracles not raised on carinae, interspiracular nodules inconspicuous (Figs. 3, 4). 2. Posterior spiracles I and III converge distinctly toward its center, forming an obtuse angle (Fig. 4). 3. Posterior respiratory process about 0.5 mm. 4. Tubes of posterior respiratory process vary from not at all divergent at the tip to slightly divergent at tip (Fig. 3).

Puparium.—Length, 5.5 mm., width, 2.5 mm., height, 2.3 mm. As in *Allograpta,* the puparium is slender and elongate. It often remains green throughout the puparial period, but may turn reddish brown. Late in the puparial period, the adult pattern is visible through the integument. The characters of the posterior respiratory process are the same as those of the larva.

Food Habits.—The larvae of this species have been taken among colonies of the following aphids: *Aphis gossypii* on muskmelons and cucumbers, *Aphis nerii* on wild lettuce, *Rhopalosiphum pseudo-brassicae* on turnips, *Amphorophora cosmopolitana* on wild lettuce, *Myzocallis alhambra* on burr and white oak, *Macrosiphum sanborni* on chrysanthemum, *Aphis viburnicola* on viburnum, *Aphis rumicis* on curly dock, *Aphis oestlundi* on evening primrose, and *Myzus persicae* and *Brevicoryne brassicae* on cabbage, kohlrabi, and broccoli. Curran (1920) lists in addition *Aphis pomi,* the green apple aphid, *Aphis cardui,* the thistle aphid, and *Myzus cerasi,* the black cherry aphid.

Sphaerophoria robusta Curran (*Sphaerophoria scripta* Fluke)

This is the *Sphaerophoria scripta* of Fluke and has been reported by him (1929) as being much more common in Wisconsin than *Sphaerophoria cylindrica.* The adults have been taken in the Urbana region rarely, but the larvae have not been seen by the writer. The larvae are slightly larger than those of *cylindrica,* averaging 11 mm.

Fluke distinguishes the larva as follows: 1. Tip of posterior respiratory process in profile, smooth. He mentions that the interspiracular nodules are even less conspicuous than in *Sphaerophoria cylindrica* (Fig. 6). 2. Posterior respiratory process is much shorter than that of *cylindrica,* from .25 mm. to .45 mm., a difference which can be distinguished by the naked eye.

Food Habits.—Fluke (1929) reared this species from *Macrosiphum (Illinoia) pisi* (Kalt.) the pea aphid.

Sphaerophoria menthastri Linnaeus

The writer has not seen any larvae of this species, but a series of puparia loaned by Dr. C. L. Fluke show, in the majority of puparia, but not all, a distinct black cross-banding on the anterior end, a feature not known to occur on the puparium of any other species of this group. Judging from other banded puparia, indications of these bands are probably not present in the larva. The posterior respiratory process, in the absence of sufficient material, cannot be distinguished from that of *robusta.*

MESOGRAMMA Loew

The larvae of the genus *Mesogramma,* as far as they have been observed, are delicate, glossy-skinned larvae which are nearly cylindrical in the mid-region, tapering anteriorly, and blunt, flattened, and emarginate at the posterior end. The integument is so transparent that the tracheal tubes and most of the internal organs are plainly visible. The posterior respiratory process is very short, and the two lowest spiracles have migrated down to the extreme ventral edge of the spiracular plate.

The most interesting single fact about this genus is the unusual food habits of the larvae. Although *Mesogramma* is not the only phytophagous syrphid (*Merodon* and *Eumerus,* the bulb flies, and *Chilosia,* recorded from living wood, are both phytophagous and saprophagous), it is one of the very few phytophagous larvae of the typically slender, maggot-like aphidophagous type and probably was originally of this habit. *Mesogramma polita* Say is the "corn-feeding Syrphus fly" described nearly fifty years ago by Riley and Howard.

A few specimens of the other known larvae of this genus, *Mesogramma marginata* Say, were reared by Fluke (1929). In spite of the fact that this is an exceedingly common species, the adults occurring by the hundreds in the summer time in open grassy places, the normal food habit of the larva is still an uncertainty. Fluke succeeded in rearing three adults from eggs laid on pea vines. The larvae were three-fourths grown before they were observed to attack a pea aphid and some developed for three days (about half the normal larval life) in cages where

no pollen or aphids were present at all. Fluke is of the opinion that they fed on the bloom of the pea leaves. Folsom (1909) gives both *Mesogramma polita* and *marginata* as aphidophagous. This was undoubtedly their primitive habit and may still be, in part, that of *marginata*, but Folsom's observations seem to be based largely on inference.

In addition to *Mesogramma polita* and *marginata*, there is a third abundant species in the Illinois region, *geminata*, the adult of which seems to prefer the open sunny places of woods and orchards. The habits of its larva are unknown, although Fluke (1929) took two larvae from alfalfa heavily infested with *Macrosiphum pisi*, but they were not separated out until they emerged as adults. Folsom (1922) lists the species as a predator. It is possible that this species may attack a root aphid in the situations where it is most abundant or may be an internal feeder in plants and has thus escaped observation.

KEY TO SPECIES OF MESOGRAMMA

Larger species, 8 mm. or more; posterior spiracular plates completely separated...*polita*
Smaller species, 4 to 6 mm.; posterior spiracular plates fused. *marginata* or *geminata*

Mesogramma polita Say

The stages of *Mesogramma polita* were described by Riley and Howard (1888). Their figures, which show the general appearance of the larva, puparium, and adult, have been repeated in many publications since. Sanderson (1900) described the larva, puparium, and imago more completely and illustrated them with actual photographs. Metcalf (1913b) pictures the posterior respiratory process of the puparium and the outline of the puparium but does not give a new description. Richardson (1915) gives no figures but an excellent biological account and a complete review of the literature.

Description of the Larva (Fig. 10).—The mature larva is 9-12 mm. long, 2 mm. wide, and 2 mm. high. It is almost cylindrical in the mid-region but tapers cephalad and ends caudally in a blunt, flattened, emarginate anal segment. Each true segment is divided into 4 or 5 subequal annulations, which gives the maggot apparently 40 regular earthworm-like rings. The integument is finely papillose and so translucent that many internal structures are readily visible through it.

The color of the larva varies with different ages and individuals. All first instar larvae are clear pollen-yellow without markings, except where the visceral contents show as a brownish mass. Second instar larvae (Fig. 11) are translucent yellow with two bright rose (often purple) stripes, immediately on either side of the dorsal blood vessel, which

pulsate with the contractions of the heart. The third instar larvae (Fig. 10) are colorless, pale straw-yellow or translucent pale-green with much softer rose or rosy-tan dorsal stripes or, more rarely, dorsal stripes completely lacking.

The anterior spiracles are small brown knobs on the second visible anterior segment. From these the main tracheal trunks run back halfway down the sides as slightly undulating silver tubes, clearly seen through the integument, and end in the posterior respiratory processes. In the anterior third, under the rose stripes, is a large, shining white fat-body.

The posterior respiratory process is sessile or nearly so, and it is unique among the syrphid larvae which the writer has examined in having the spiracular plates completely separated from one another (Figs. 10, 12). They appear as two light brown spots on the upper surface of the flattened, emarginate anal segment. The arrangement of the spiracles is striking; the upper spiracle is only half as long as the others and isolated by more than twice its length from the other two. The latter are crowded down to the ventral edge but not reduced in size. Rectal gills appear to be absent.

Puparium (Figs. 13, 16, 18).—The puparium is 7-8 mm. long, 2.4 mm. wide at the widest point, and 2 mm. high. It is club-shaped, rounded anteriorly, and tapers gradually to the anal segment, which is broader and flatter than that of the larva. The regular annulations of the larva have disappeared, and a carina is present immediately anterior to the posterior spiracles. The puparium is at first lucid yellow or greenish and retains the rose-colored stripes of the larva; it then changes to a clear opaque tan, variously pencilled with dark lines, which have no relation, apparently, to the color markings of the larva. When fully marked there is : (1) a median dorsal longitudinal line which may extend from the apex of the puparium to the posterior respiratory process, (2) a well defined longitudinal lateral line halfway down each side for about three-fourths the total body length, (3) a broken, undulating, sub-dorsal line on each side, midway between the last two, and (4) a sub-lateral, broken line on each side below the lateral line. The presence of the lateral lines alone are the commonest condition, but all may be absent.

The posterior processes differ from those of the larva in that they are more or less united by a brownish hardening of the integument between them, and the spiracles are heavily ringed with black.

Food Habits.—The first instar larvae were found in quiescent masses of a hundred or more lying closely packed and parallel to one another under the upper leaf sheaths of sweet corn. On being disturbed, they become very active, moving rapidly about with a looping motion. When at

rest, they seek the moist situations about the plant, probably because of their delicate skins. At this stage they are engorged with yellow pollen and are rich yellow. In the second instar they are exactly the same size and of much the same shape as a single corn anther; the groove of the anther is mimicked by the double dorsal stripe. Thus, when seen out on the leaf, lying quiet, they resemble a fallen anther among the pollen on the leaf surface. They are scattered farther down the stalk than the first instar and probably feed on juices of the plant as well as pollen.

Adult larvae were observed later beneath every leaf sheath from the top to the base of the corn stalk, in small groups of three or four, scraping away industriously at the succulent tissues of the leaf sheath and leaving wet patches of broken cells. That they also feed on pollen is shown by golden yellow, or brownish, visceral contents, but some show only clear translucent bodies, indicating that they feed on exuding sap alone. The mature larvae, with their soft green or straw-colored bodies and purplish dorsal lines, mimic the purple-veined glumes of the corn tassel. Some are found here as well as under the leaf sheaths and on the blades. Their habit of pupariating head downward among the florets of the tassel and their shape and coloration makes them almost indistinguishable from the true florets. Under the leaf sheaths and in the crevices of the ear husks they also pupariate head downward, often in such pools of sap and dew that only the posterior spiracles, now uppermost, protrude from the liquid.

Mesogramma marginata Say

The only available description of this species is given by Fluke (1929), who succeeded in rearing it from eggs in the laboratory. He figures the puparium and the posterior spiracular plates.

Description of the Larva (Fig. 14).—Fluke (1929) describes the larva as follows: "4 to 4.5 mm. long, 1 mm. wide. Body light greenish yellow. The only dark areas are where the viscera show through. Integument transparent, very slightly papillose. Segmental spines very short and light in color; no integumental vestiture.

"The posterior respiratory organ situated on a papillose base which is as high as the appendage is long. The chitinous ring is not very strong and surrounds the entire organ with gentle indentation curves both dorsal and ventral. In the evolutionary development of this species, spiracles II and III have migrated so that II now occupies the position of III. This also means that the inner or mesal ends of the spiracle were once the outer or distal ends."

Puparium (Fig. 15).—This description is also quoted from Fluke (1929).

"Length 5.2 mm., width 1.5 mm., widest at the front one-third; evenly

rounded anteriorly, tapering gradually to rear. Ventral line almost straight. Two prominent irregular, curved dark lines along the sides, the more dorsal one running from near the front end to within 1 mm. of the rear. Lower line a little more than half as long as the pupa."

Food Habits.—Not known.

Mesogramma geminata Say

The larva of this species is unknown, but Dr. C. L. Fluke has kindly loaned a puparium from which the drawing of the posterior spiracles and the following description are made:

Puparium.—Length, 7 mm., width, 2 mm., height, 2 mm.; broad and evenly rounded at anterior end and tapering evenly toward the rear. The color is light golden-brown. Two dark lines are present along the sides in the same position as those in *marginata* and of about the same extent. The posterior spiracular plates (Fig. 17) are contiguous in the puparium, and from their structure were evidently so in the larva as well. The spiracles, as in the other puparia of *Mesogramma,* are raised on blackened carinae.

Food Habits.—Not known.

Melanostoma Schiner and *Platychirus* St. Fargeau and Serville

Although the males of these two genera appear to be distinct, the females are very difficult to assign even to genus. The larvae, also, are so similar as to make it impossible up to the present to distinguish the genera.

The larvae of the two genera are both smooth, glossy-skinned, slightly flattened, and maggot-like. They are characterized by an unusual transparency of the integument and by almost sessile posterior spiracular plates which have a dark triangular field around them.

The larvae of both genera are nocturnal and show a strong preference for quite moist situations. When disturbed, they become very active and display the most remarkable speed of travel that the writer has observed in any syrphid.

The two genera seem to present a transition group in food habits. Metcalf (1916) records finding a large number of *Melanostoma mellinum* larvae on rape plants infested with *Myzus persicae,* but the aphids were much fewer in numbers than the predators. He reared the larvae in the laboratory on *Aphis cornifoliae* Fitch and *Myzus persicae,* but the larvae refused other species. Davidson (1922) observed that *M. stegnum* raised on a diet of aphids became undersized imagines, suggesting that aphids were not their normal diet. He records the observation of Curran

that the larvae of *M. obscurum* consumed both aphids and decomposing chickweed and that they were more successful on the chickweed. In Davidson's cages, there was no decomposing plant material. He makes an interesting suggestion: "It is possible that several of the species of *Melanostoma* are both phytophagous and entomophagous in the larval stage, and that even these are undergoing a transition in habit, changing from plant to insect feeders. The nocturnal habit of feeding and desire for concealment suggests that it may not have been so long ago that the larvae normally lived in obscurity inside plants, or in the open in darker situations than growing plants normally afford."

The larvae of *Platychirus quadratus* have been taken by the writer on rape where there was an apparent absence of aphids. On the other hand, Metcalf (1917) reared *P. perpallidus* from eggs in the laboratory on *Aphis cornifoliae,* and Fluke (1929) records taking hundreds of the larvae of *P. hyperboreus* from alfalfa infested with *Macrosiphum pisi.* He also collected *P. quadratus* among *Hyalopterus pruni* (Geoffroy), an aphid of *Phragmites.* Verrall (1901) states that *P. scutatus,* an European species, "is said to have been bred from rotten fungi." Although the latter record is doubted by some authors, it may be said that the larvae of *Platychirus* exhibit a tendency toward variable feeding habits similar to that of *Melanostoma.*

Of the following species, the writer has seen the living larvae of *Platychirus quadratus* only, although she has been able to examine several species of puparia. The characters of the puparia and those given in the descriptions of other authors have been insufficient to separate the species in this group.

Melanostoma mellinum Linnaeus

The larva and puparium have been described in detail and figured by Metcalf (1916). The author has not seen the larva of this species, and the following description has been taken from his paper. The description of the puparium was made from a single specimen in the immature collection of the Department of Entomology at the University of Illinois.

Description of Larva.—Length, when well extended, 8-9 mm., width 2.5 mm. Color lettuce-green, a little more yellowish mediad. Since the integument is unusually transparent, the viscera show through the body wall with unusual plainness.

The integument is finely papillose without vestiture. The segmental spines consist of a fleshy, subconical base surmounted by a slender, blunt peg of about equal height, the whole small, light colored, entirely inconspicuous.

The posterior respiratory process is about 0.3 mm. broad at the end, about 0.17 mm. in height and elevated above the surface of the last

segment only to a length of about 0.1 mm. The circular plate is evident, and the pairs of spiracles are unusually short: less than twice as long as broad. The interspiracular ornamentation consists of four pairs of short rounded nodules. There is a moderate emargination between the two posterior spiracular plates.

Puparium (Fig. 19).—Length, 6 mm., width at anterior end, 2.25 mm., height, 1.7 mm. General body form clavate, sloping in narrow ridge down to posterior respiratory process. Color yellowish green, translucent, with tendency towards opalescence.

Under either the highest power of a binocular miscroscope or under the low power of a compound microscope, the pupal respiratory horn is clearly evident as a small reddish brown projection rising from the dorsal plate of the operculum. It is slightly longer than its diameter. The eight oval areas figured by Metcalf (Fig. 19) are difficult to see on the specimen examined by the writer. The features of the posterior respiratory process are the same as those of the larva, but the spiracles are surrounded by a black triangle.

Food Habits.—From eggs deposited on rape, and larvae found in moist places near the ground under the leaves of rape, Metcalf (1916) reared this species in the laboratory on *Myzus persicae* and *Aphis cornifoliae* Fitch from *Cornus.* His records do not absolutely establish whether the larvae were aphidophagous in the field or were feeding on rotting material in the moist situations at the base of the plants.

Melanostoma obscurum Say

The adults of this species are not uncommon in the Illinois region and are very generally distributed over the United States. The author has reared puparia loaned by Dr. C. L. Fluke but is unable to distinguish these in any way from those of *M. mellinum.* The posterior spiracular plates are shown in Fig. 21.

Platychirus quadratus (Say)

The puparium and posterior respiratory process of this species were figured by Metcalf (1913) but no description was given. Fluke (1929) figures the posterior spiracular process and a parasitized puparium.

Description of the Larva.—Length, 10-12 mm., width, 2.25 mm., height, 2 mm. The color is bright, rich orange to translucent orangish brown with the visceral bodies variously modifying the general coloration through the transparent integument. There are two dull white sublateral visceral lines similar to those in *Sphaerophoria* (Fig. 1).

The body is distinctly spindle-shaped with a broad, flat, truncate

posterior segment. The secondary wrinkles are slight and inconspicuous, the segmental spines minute.

The posterior respiratory process is a light reddish brown, almost concolorous with the body color and projects but slightly above the surface. The three posterior spiracles are located in a roughly triangular field, frequently darker than the rest of the plate, and always so in the puparium. The writer has been unable to find in *P. quadratus* the denticles along the sides of the spiracles as described by Metcalf for *P. perpallidus*. The interspiracular nodules are exceedingly minute and located on the triangular field. The circular plate is prominent, with a distinct rim and fine radiating lines in its disk.

Puparium.—Length, 6 mm., width, 2.5 mm., height, 2.3 mm. The shape is more inflated than that figured for *Melanostoma mellinum* (Fig. 19) having a distinct convexity posteriorly. The color is strawy-tan; in later puparia, the pattern of the adult shows through the puparium. The posterior respiratory process is similar to that of the larva except for increased pigmentation around the spiracles.

Food Habits.—The larvae were reared from eggs laid by adults caught hovering around rape; they were reared in the laboratory on *Myzus persicae.*

Platychirus hyperboreus Staeger (= *Platychirus erraticus* Curran)

The stages of this species are very completely described by Fluke (1929) from Wisconsin where it is a very important predator of the pea aphid. He figures the puparium and the posterior spiracular plate, and gives in addition photographs of eggs, a larva, and puparia. The species occurs in Illinois but the larvae have not been seen by the writer. The following descriptions have been condensed from Fluke's account.

Description of the Larva.—Length, 11-11.5 mm., width, 2.5 mm., height, 2 mm. The predominating color is pinkish salmon with the adipose tissue showing through principally as two sublateral lines. On each side of the dark and prominent heart line are several very irregular, interrupted lines of white.

The body is decidedly pointed anteriorly, the wrinkling gentle with few folds. The integument is very finely papillose without any spiny vestiture. The segmental spines are short, white, and inconspicuous.

The posterior spiracular plates are so similar to those of *P. quadratus* that the writer is unable to distinguish the two; Fluke gives the following tentative, but admittedly weak, distinguishing characters: *P. hyperboreus:* spiracles appear wider, circular plates with radiating, spreading grooves; *P. quadratus:* spiracles longer and more slender, circular plates with radiating, spreading lines, not grooves.

In this species, as in *P. quadratus,* the denticles around the spiracles described by Metcalf for *P. perpallidus* are lacking.

Puparium.—Length, 6 mm., width, 2.5 mm., height, 2.3 mm. Light brown in color. A few days before emergence the pattern of the adult becomes discernible.

Food Habits.—Fluke reared this species from *Macrosiphum pisi* on peas and alfalfa.

Platychirus perpallidus Verrall

The stages of this European species were described very carefully by Metcalf (1917) from Maine. His account is accompanied by figures of the eggs, larva, puparium, and adult. The description is taken from Metcalf's account.

Description of the Larva.—Length 10-11 mm., width at middle, 1.72-2 mm., height, about 2 mm. An elongate, slender-bodied larva with moderate wrinkling and gently irregular margin. The color is a beautiful bright tan. On each side of the darker heart line is a broad, whitish stripe of adipose tissue, giving off at the sides irregular curved tongues of white which form an indefinite broken stripe of white. A third pair of whitish stripes, slender, broken, and irregular, lie close to the lateral margins.

The posterior spiracular plates (Fig. 20) are almost sessile, the respiratory process being about 0.18 mm. long. The circular plates are distinct, the interspiracular nodules very small. Each spiracle has a row of separate minute rounded denticles along its margin, increasing its apparent width.

Puparium.—Length, 5.5 mm., width, 1.85 mm., height, 1.75 mm. The colors of the larva are at first carried over into the puparium but are gradually transformed to a uniform reddish brown. In side view the puparium is moderately inflated; from the maximum height about the anterior third it descends in a moderate hump over the posterior third to the posterior respiratory process.

Food Habits.—This species was reared in the laboratory on *Aphis cornifoliae* and *Aphis spiraecola* Patch by Metcalf (1917).

Lasiophthicus Rondani

The representative of this genus, *Lasiophthicus pyrastri* Linnaeus, is a typically western species where, according to Essig, (1926), it is the most abundant and beneficial as well as the best known syrphid. He says it is found in every western state, including British Columbia in Canada. The larvae are voracious and general feeders and the adults strong fliers. Fluke (1929) believes that it would be practical to introduce this valuable

species into Wisconsin, where another western species, *Eupeodes volucris*, has already become established accidentally. Because this species is so important in the West and may eventually become common in Illinois, it has been included in this paper.

Lasiophthicus pyrastri Linnaeus

The larva and puparium of this species were described in detail and figured in colors by Jones (1922). Campbell and Davidson (1924) describe the same stages rather briefly and discuss the food habits; they give a photograph of the larvae. Essig (1926) discusses the stages briefly in "Insects of Western North America." Fluke (1929) figured the posterior spiracular plates, and a description of their features was given.

For this species, three names are in common use, *Scaeva pyrastri*, *Catabomba pyrastri*, and *Lasiophthicus pyrastri*. The writer is following Aldrich in using *Lasiophthicus* as the generic name.

The material for the drawings was kindly loaned by Dr. C. L. Fluke and came originally from California. The descriptions have been in part adapted from the authors mentioned above and in part taken from preserved specimens.

Description of the Larva.—Average length, 14-16 mm., width, 3.5 mm. Pea-green to a brownish green, a lighter green anteriorly and more yellowish posteriorly, with a narrow dorsal, longitudinal, white stripe and two fainter and more irregular white dorso-lateral stripes, growing darker posteriorly. The line of the dorsal blood vessel is inconspicuous.

The body is subcylindrical, tapering anteriorly and truncate posteriorly, irregular in outline and very much wrinkled transversely. The segments are distinct. The integument is papillose and covered with microscopic pale setae. The segmental spines are short and inconspicuous.

The posterior respiratory process (Fig. 24) is dark brown and is shorter than the combined width of the tubes, basally contiguous and apically slightly divergent. The most characteristic feature is the position of spiracle II, which has shifted around and downward with the result that spiracles II and III are approximately parallel. The dorsal spine is wanting altogether. The circular plates are surrounded entirely by a thickened rim. The interspiracular nodules are minute and inconspicuous.

The chitinous bars (Fig. 22) in the posterior spiracles of this genus are more closely related to those of *Syrphus* than *Metasyrphus*. They consist of an irregular fringe of minute pegs on slightly different levels protruding into the openings. On the tips of every third or fourth peg is a slender rod, enlarged at the end.

Recognition Characters.—1. Large larvae (10-15 mm.) varying from green to brownish green with white longitudinal stripes. 2. Posterior

spiracles II and III approximately parallel and directed dorso-ventrally (Fig. 24). 3. No dorsal spine on posterior spiracular plate.

Puparium (Fig. 28).—Length, 8.5 mm., width, 3.5-5 mm., height, 3-3.5 mm. General color dark brown, tinged with pink. Anterior end inflated, tapering abruptly from beyond the middle to the posterior end. Dorsum broadly convex, venter fairly straight, slightly concave toward the posterior end. The posterior, rather square segment curls down under the body on pupariation in a characteristic little lip, exposing more fully the dark brown posterior respiratory process. The features of the spiracular plates are the same as those in the larva (Fig. 24).

Food Habits.—This species, like *Syrphus* and *Metasyrphus,* is a very general feeder. Jones (1922) records individuals from *Periphyllus negundinis* (Thomas) on box-elder, and he reared them successfully from *Aphis helianthi* Monell, *Aphis avenae* Fabr., *Aphis carbocolor* Gillette, *Brevicoryne (Aphis) brassicae, Aphis pomi* de Geer, *Macrosiphum solanifolii* (Ashm.), *Myzus cerasi,* and *Clavigerus* (*Melanoxantherus*) *bicolor* (Oestlund). He noted that in the cages they were even cannibalistic. Campbell and Davidson (1924) record them, in addition, from *Aphis gossypii, Aphis maidis, Brevicoryne pseudobrassicae, Macrosiphum pisi, Macrosiphum albifrons* Essig, *Macrosiphum rosae* (Linn.), *Myzus persicae,* and *Chromaphis juglandicola* (Kalt.).

EUPEODES Osten Sacken

Three species of the genus *Eupeodes* have been described. The best known, *volucris,* is a typically western syrphid and is one of the most abundant and important aphidophagous species of western United States, occurring in California throughout the entire year, according to Campbell and Davidson (1924), and especially in arid regions, according to Fluke. The writer has never collected specimens of this fly in Illinois and there are none in the collection of the Illinois State Natural History Survey, but Fluke (1929) records six specimens from Wisconsin between 1919 and 1926 and thinks it may in time become common in the Middle West.

The genus is very closely related to the genus *Syrphus,* and the larvae resemble those of *Syrphus,* being long, rather slender, and tapering anteriorly. Like *Syrphus,* they have a very short posterior respiratory process. The segmental spines are conspicuous. The most striking feature, which may be a generic one, is a peculiarity of the spiracular plates in which the angle between spiracles I and II is very great, so that the three spiracles are almost parallel to one another. No other syrphids show such complete divergence of the two upper spiracles, although, as Fluke has pointed out, *Lasiophthicus pyrastri* and *Syrphus meadii* approach it, but they are readily distinguished by other characters.

Eupeodes volucris Osten Sacken

Jones (1922) described the stages and figured the larva and puparium in colors. Smith (1923) gave a figure of the larva but no description. Campbell and Davidson (1924) also described the immature stages and gave a figure of the mature larva and a photograph of a partly grown larva. Fluke (1929) describes the posterior respiratory process and gives a figure of the spiracular plates.

The following descriptions were made from living larvae and puparia reared in Colorado by the writer.

Description of Larva (Fig. 25).—Length of mature larva, 9-14 mm., width, 2-3.25 mm. Typical maggot-like form tapering anteriorly, somewhat flattened and truncate posteriorly. The larva has a moderately spiny appearance, due to conspicuous segmental spines which consist of a long, blunt, peg-like distal segment on a broad basal segment (Fig. 26).

The color of the larva usually presents a greenish general appearance, streaked dorsally with soft pink and white, yellow and white, or green and white. A broad median band along the dorsum varies from soft flesh-pink, dull salmon, or yellowish to leaf-green. It is bordered laterally by two narrow, irregular white lines which follow the ridge of the dorsolateral segmental bristles. Beyond these lines on each side the sides and venter are soft leaf-green, rarely dull straw-yellow. The median dorsal blood vessel is very narrow and inconspicuous. On the four segments just anterior to the posterior respiratory process are oblique brownish lines of variable distinctness due to minute brown cutaneous speckling.

The posterior respiratory process is light golden brown and normally recessed in a fleshy depression, so that in a living larva it is usually invisible from above. The process is short with a characteristic ventrolateral chitinized lobe at the base of each tube. Only the upper spiracles have a carina. A sharp dorsal spur is present. The arrangement of the spiracles is distinctive, with spiracles II and III nearly parallel and vertical in position.

Recognition Characters.—1. Segmental spines in form of a blunt peg, four times as long as wide, on broad basal segment (Fig. 26). 2. Posterior respiratory process short (Fig. 23) with sharp dorsal spur, and the two lowest spiracles of each side approximately parallel to the median axis.

Puparium.—Length, 5.5-6.5 mm., width, 2.5-3 mm. Dorsum broadly convex; venter almost straight or slightly concave; the posterior end with a tendency to turn down under sole at tip. The color varies from light dun-brown to rich brown and may have from four to seven dorso-lateral black spots formed by the concentration of the brownish, oblique stripes of the larva. The prominent peg-like segmental spines are visible all

over the surface as translucent yellow tags if the puparium is clean. Often it is covered with dirt from the soil surface on which pupariation usually occurs. The posterior respiratory process is more prominent than in the larva, since the contraction of the integument causes it to be exserted, but the recognition characters are the same.

Food Habits.—Eupeodes volucris has been reared from *Periphyllus negundinis* on box-elder, *Aphis helianthi* on *Cornus, Aphis viburnicola* on snowball, *Myzus cerasi* on cherry, and *Capitophorus ribis* (Linn.) on currant. Jones (1922) also records it from *Aphis carbocolor* on *Rumex, Pemphigus betae* Doane on beets, *Macrosiphum pisi* on alfalfa, and from *Aphis avenae* on cat-tail. Campbell and Davidson (1924) have taken it on *Brevicoryne brassicae, Brevicoryne pseudobrassicae, Aphis gossypii, Aphis maidis, Aphis rumicis, Macrosiphum rosae, Myzus persicae, Myzus braggii* Gillette, *Rhopalosiphum lactucae* Schrank, and *Myzocallis californicus* var. *pallida* Davidson, hosts not given. Smith (1923) lists it as an important predator of *Anuraphis bakeri* Cowen, the clover aphid.

SYRPHUS Fabricius

The genus *Syrphus* contains some of the commonest and most conspicuous of aphid predators. So far as is known all the species of this genus are aphidophagous and are general feeders, found on many species of aphids.

The larvae are medium-sized or large (10-17 mm.) robust maggots. They are bare of bristles except for the very minute and usually pale, scattered segmental spines (Fig. 34). The integument, however, is pebbled with very small, hyaline, rounded papillae. The posterior respiratory process is very short and appears smoothly rounded because the interspiracular nodules are small and there are low, or no, carinae around the spiracles (Fig. 31).

The spiracles are peculiar for a fringe of minute parallel bars (Fig. 35) guarding the opening just below the surface of the rim. These may be plainly seen under the high power of a compound microscope in the spiracles of any of the species of this group. Below the fringe of bars is a broadly fusiform basket of large chitinous bars which appears to strengthen the walls of the atrium. Their presence gives a slightly bulbous swelling (Fig. 30) to the surface around the spiracle. The swelling is not great enough to be considered a carina and may be altogether lacking in some specimens.

The color pattern follows a similar design in all the species (Fig. 29). The dorsal blood vessel is a dark median line which may be brown or black. On each side of the dorsal blood vessel runs a very narrow in-

terrupted band of a bright color which the writer has called the *dorsal line.* Each dorsal line usually has at the same relative point on each segment, a knot-like thickening. Laterad from the dorsal line is an open area of translucent brown or dense black. It receives its color from the internal fluids and is limited in shape and size laterally by fatty masses; since this area, combined with the symmetrical one of the same segment, is usually in the shape of an arrowhead pointing forward and broadly joining the same area in the next segment, it has been called the *arrow.* The large fatty masses, which run midway down each half of the larva and form a segmented pattern of wedge-shaped areas, have been called the *chevrons.* These are yellow, white, or pale pink and grow more extensive in the late larvae, invading and obliterating the brownish or black arrows. When the accent of dark color is removed, and with some fading of the dorsal line, the whole bright pattern changes to a monotonous pinkish yellow or white, and accounts for the fact that two larvae of apparently very different color patterns are the same species.

The larvae of the genus *Syrphus* are readily distinguished from those of the most closely related genus, *Metasyrphus,* by a lack of spiny vestiture which is present in *Metasyrphus;* by a smoothly rounded spiracular plate with no high carinae, while the plate is angular with high carinae in *Metasyrphus;* by the presence of parallel chitinous bars in the spiracle of *Syrphus* but a perforated plate in that of *Metasyrphus;* and by relatively more robust, broader larvae than those of *Metasyrphus.*

The rectal gills are a pair of double finger-like structures joined at the base, one pair on each side of the rectum. They are alike in all of the species (Fig. 32).

KEY TO SPECIES OF SYRPHUS

(Colors are those of living specimens)

Posterior respiratory process with large, high, irregularly ridge-like interspiracular nodules; process twice as long as height at tip (Figs. 38, 39) .... *S. knabi*

Posterior spiracular tube with smoothly rounded, or oval interspiracular nodules; tube usually only about as long as it is high (Figs. 30, 31) 1

1. Nodules all located close in to center of spiracular plate, and of about the same size and shape; the circular plates distant from dorsal margin by three-fourths their height; usually smaller larvae (Fig. 33) .... *S. torvus*

   Nodules not all same size and shape nor close in towards center; circular plates less than one-half their height distant from the dorsal margin; usually large to very large larvae (Figs. 30, 36) 2

2. Red, black, and yellow and over 14 mm.......... *S. ribesii vittafrons* (Fig. 36)

   All white, or all pink chevroned, or red, brown, and white and not over 14 mm.......... *S. rectus* (Fig. 29)

Syrphus rectus Osten Sacken

So far as the writer knows this larva has not been described. Fluke (1929) figures the posterior spiracular plate and compares it briefly with those of *S. ribesii* and the variety *S. ribesii vittafrons*.

This species is common from spring until late in the fall and with *S. ribesii vittafrons* makes up the majority of the larvae of *Syrphus* found in this region. Unfortunately, the larvae of the two species, unless in full coloration, are very difficult to distinguish.

Larva (Fig. 29).—Length, 13 mm., width, 3.5 mm., height, 3 mm. The larva is a rather large, robust maggot, somewhat broader than high with a glossy, smooth skin crossed by numerous shallow wrinkles. The integument is bare but covered with rounded hyaline papillae (Fig. 34). It is perfectly transparent so that the color pattern of the larva is formed by the colors of subcutaneous structures.

This species appears to occur in two color forms. In the spring, the chevrons are white or salmon pink, very large, and cover most of the area normally occupied by the arrows. The general appearance is of a largely white or pink larva with a slender black dorsal line, interrupted, as if dotted, with four slender black diagonal lines on each side, directed caudad, forming four V's with their points forward. The dorsal line is not distinguished from the chevrons, but sometimes the fatty masses are yellowish or tinged strongly with pink only near the midline. The sides are always translucent greyish white.

In the summer and late autumn, the larva is a beautiful snake pattern of russet brown and white. The dorsal blood vessel is a black median line bordered on each side by a rich brick-red dorsal line. The arrows are deep brown to black, but in either case to the unaided eye they appear, with the red, as a rich brown dorsal stripe. The chevrons are dead white and the lateral margins brownish, translucent, light grey. As this larva approaches pupariation, the chevrons become more extensive, obliterating the black, and the red dorsal line becomes paler. Soon the black has completely disappeared; the chevrons take on a salmon cast and the brown and white larva becomes a dull pink very similar to a late stage of either *ribesii vittafrons* or *torvus*.

The posterior respiratory process (Fig. 31) is just about as long as it is high at the tip (about 0.3 mm.). The posterior spiracular plate (Fig. 30) is disc-like, smooth, and evenly rounded at the edge. On each plate are three pairs of simple spiracles and four pairs of small, distinct, well-rounded interspiracular nodules; the circular plates are somewhat higher than broad. There is a prominent curved ridge mesad from each spiracular plate, a structure corresponding to the dorsal spine

of other genera. Fluke believes the posterior respiratory organ smaller in *S. rectus* than in *S. ribesii vittafrons* and *S. torvus*.

Recognition Characters.—Usually smaller than that of *Syrphus ribesii vittafrons*. The nearly all white, or the russet brown and white pattern is readily recognizable, but when in the pinkish dun stage, the larva looks like that of *S. ribesii vittafrons*. The posterior spiracles afford no known distinctive characters.

Puparium.—Length, 7 mm., width, 2.8 mm., height, 3 mm. The puparium, in contrast to the larva, is rather readily distinguished from the pupa of *ribesii vittafrons*. It is slender, not inflated in outline, and somewhat smaller than the other species. It has a distinctive black lattice-like pattern of X-shaped bars on the sides, against a background of light tan. There is a wavy, tan, lateral line. The dorsum is usually an unmarked tan except for a few median black dots or bars near the posterior respiratory tube. A very few puparia show no color markings.

Food Habits.—The larvae of this species have been taken by the writer among *Aphis spiraecola* Patch on flowering almond and *Aphis viburnicola* Gillette on viburnum in the spring; among *Rhopalosiphum rhois* Monell on sumac and *Aphis rumicis* Linn. on curly dock in the summer, and among *Myzocallis alhambra* on oak, *Aphis oestlundi* Gillette on evening primrose, *Myzus persicae* on cabbage, *Macrosiphum gei* (Koch), and *Macrosiphum ambrosiae* (Thomas) on wild lettuce in autumn. Fluke records it from *Macrosiphum pisi* on peas in Wisconsin. At Urbana, it was taken by Mr. B. D. Burks feeding on *Cinara laricis* (Hartig) on larch.

Syrphus ribesii Linnaeus

Syrphus ribesii is a large species found only in the northern and western regions of the United States. The writer has seen no specimens of the larva, but it is presumably similar to its variety, *ribesii vittafrons*, which is abundant in Illinois. Fluke (1929) gives a figure of the posterior spiracular plate and compares it with *vittafrons*. He lists it as a rare predator of *Macrosiphum pisi* on peas in Wisconsin.

Syrphus ribesii vittafrons Shannon

This larva is extremely common in June and again in the fall; the writer has found it very scarce during August. This may be due to two generations a year or to accidents of the two seasons in which the work was carried on. Fluke has figured the posterior spiracular plates and given the measurements of the larva; his description of the larva is very brief.

Larva.—Length, 12-15 mm. at rest, 17 mm. or more when extended, width, 3.5 mm., height, 2.8-3 mm. This is easily the largest known larva of the *Syrphus* group. Otherwise it is very similar in its robust shape to the others.

The color pattern at its brightest is quite striking; jet black, bright red, and yellow. The dorsal line is scarlet, the arrows black and the lateral chevrons clear rich yellow or cream. The sides are translucent grey or dun. In late larvae, the dorsal line fades to pinkish orange, or yellow with pinkish knots; the chevrons take on a salmon-pink cast; the black fades out of the arrows leaving them narrow and grey. The result is a pinkish yellow, vaguely snake-patterned larva very similar to that of *S. rectus* and *S. torvus.* The spiracular plate (Fig. 36) cannot be distinguished from *rectus* by any constant characters.

Puparium (Fig. 37).—Length, 8 mm., width, 4 mm., height, 4 mm. The puparium is very large and has an inflated appearance. It is evenly rounded at the anterior end, curves gently down for three-fourths of the body length and then bends abruptly to the base of the posterior tube. The integument is light yellow-brown with a silky sheen and no trace of any dark markings. The integument is smooth but marked with numerous tiny parallel lines, traces of the larval wrinkles.

Food Habits.—The larvae of this species have been taken among *Aphis viburnicola* on snowball and *Aphis rumicis* on curly dock during June and July. In the fall, it was taken among *Macrosiphum rudbeckiae* (Fitch) on wild golden-glow and *Macrosiphum sanborni* Gillette on chrysanthemum, among *Macrosiphum ambrosiae* (Thomas) on *Verbasina* and wild lettuce. In addition, Fluke lists this species from *Macrosiphum pisi* in Wisconsin.

Syrphus torvus Osten Sacken

The larva and puparium were described in detail by Metcalf (1911a) and a figure of each, accompanied by enlarged details, was given. Later, briefer descriptions by the same author were published in 1913 and 1916. Fluke (1929) does not describe the larva but gives the characters of the larval posterior spiracular plates and figures them. According to Metcalf (1913) the larva has also been described by J. B. Smith (1890); the writer has not seen this paper.

Syrphus torvus is most common in Illinois in the spring, and only a few were reared during the summer in comparison with great numbers of other species of *Syrphus;* however, it is widely distributed over the United States. The adults vary considerably in size from rather small flies to large robust individuals.

Larva.—Length, 10-13 mm., width, 3-4 mm., height, 2.5 mm. In the

second instar the larvae are ebony black, brick red, and white; the black gradually becomes brown, and in the third instar the general coloration is brownish pink with yellowish chevrons. The coloration is deceptively similar to that of the larvae of *S. ribesii vittafrons,* but the larvae of *S. torvus* are smaller in general.

The posterior respiratory process (Fig. 33) is short, not more than one and a half times the height of the tube at its tip. The spiracular plate is very smooth and rounded, with small distinct interspiracular nodules, placed unusually close to the center of the plate. There is a broad shoulder of the spiracular plate above the circular plate, about three-fourths the height of the circular plate itself; this distance to the edge is much greater than in any other known species of this group and is accompanied by a shift of the dorsal spur nearly to the midpoint of the spiracular plate.

Puparium.—Length, 7-10 mm., width, 4 mm., height, 4 mm. Light golden brown, naked, smooth, and with a silky sheen. In some specimens there is a series of six or seven small black dots in a median dorsal row from the anterior curve back to the base of the projecting respiratory tube; curving along each mid-lateral region is a wavy, slender, dark lateral line. The characteristics of the posterior respiratory process are the same as those of the larva.

Food Habits.—The larvae have been taken among *Macrosiphum ambrosiae* on wild lettuce *(Lactuca)* and *Verbasina,* among *Macrosiphum sanborni* on chrysanthemum, and among *Macrosiphum rudbeckiae* on wild golden-glow. Metcalf records them from *Aphis brassicae* on cabbage, more rarely among *Longistigma caryae* (Harris) on sycamore in Ohio, from *Aphis spiraecola* on spirea, and from *Phorodon humuli* (Schrank) on plum seedlings in Maine. Fluke records this species from *Macrosiphum pisi* in Wisconsin.

Syrphus knabi Shannon

The immature stages of *Syrphus knabi* were first described by Metcalf (1913a) under the name *Syrphus xanthostomus* Will., with some doubt as to its identity; the accompanying plate gave an outline of the larva and puparium and several details of the larva. A briefer description by the same author is given and figured in "The Syrphidae of Ohio" (1913b). In 1916, Shannon described the adult as a distinct species, and the following year Metcalf (1917) redescribed the larva and puparium under the new name of *Syrphus knabi.*

The larvae seem to prefer aphid colonies in protected situations. In Ohio, Metcalf reared this species from the vagabond galls of poplar and American aspen, where they fed on the gall-forming aphid *Pemphigus oestlundi* Cockerell. In these cramped quarters they were strongly arched,

stoutly broad, and very sluggish. In Maine, the larvae were found in the tightly curled leaves of ash caused by *Prociphilus fraxinifolii* (Riley). The writer found the larvae only in the tightly curled leaf-rolls of *Georgiaphis ulmi* (Wilson). Such situations are almost as well protected as within the cavity of the vagabond gall; these latter larvae were not so limited in their positions and consequently were not exceptionally thickened and shortened, nor were they so sluggish as the first. They are, however, quite robust larvae. It is interesting to note that all the aphid hosts are pulverulent.

Larva.—Length, 14-15 mm., width, 4 mm., height, 3 mm. Broad, thick larvae of the usual *Syrphus* type; general coloration, rosy pink and white of rather indefinite pattern. The ground color is soft, translucent grey overlaid with pink or orange visceral globules alternating with white in the typical segmented chevron pattern. The dorsal blood vessel shows as an interrupted median black line; the sides and venter, greenish translucent grey. The posterior respiratory process is bright brown.

The segmental spines of *S. knabi* are sometimes quite prominent under the microscope because they are usually bright brown like the posterior process. However, they are small and short and, to the naked eye, nearly indistinguishable.

The posterior respiratory process (Fig. 39) is notably longer than that of any of the other *Syrphus* species. In lateral view, it is slightly more than twice as long as it is high at the tip. In *torvus* the length does not exceed the height at the tip. Beyond the middle of the tube is a slight constriction; proximal to this the tube is darker brown, slightly rough, and dull in texture; distally, a clear, translucent polished brown. The interspiracular nodules of the posterior spiracular plate (Fig. 38) are unusually high and roughened, especially those of the ventral outer angle which are irregular carinae extending over the edge of the plate. All are much higher than the spiracles. The plate-like ridge at the dorsal inner angle of the spiracular plate is well developed.

Puparium.—Length, 7 mm., width, 3.5 mm., height, 3.5 mm. Color, light golden, shining brown. The puparium is often more or less marked with black; the most fully colored specimen has five V-shaped dark bands on the dorsum, the points directed caudad. The puparium is of the usual nearly rounded shape of this group but not so inflated as that of *S. ribesii vittafrons*. The posterior respiratory appendage has the same distinctive characteristics as that of the larva.

Food Habits.—*Syrphus knabi* has been taken in the larval stage feeding on *Georgiaphis ulmi* (Wilson) in curled leaves of slippery elm *(Ulmus fulva)* and, by Metcalf, on *Prociphilus fraxinifolii* in the curled leaves of

ash (*Fraxinus* sp.) in Maine and on *Mordwilkoja vagabundus* (Walsh) in the galls of aspen *(Populus tremuloides)* in Ohio. Fluke has recorded this species from *Macrosiphum pisi* on peas.

METASYRPHUS Matsumura and Adachi

The genus *Metasyrphus* contains a large number of species, but the larvae are difficult to separate and in some cases have been described under several names. This genus, like *Syrphus,* includes some of our commonest and most economically valuable species; all are general feeders on many kinds of aphids.

The larvae are medium-sized to large (10-15 mm.) but the larvae of the commonest species, *Metasyrphus wiedemanni,* as a rule, are smaller than *Syrphus* larvae. They are slenderer maggots, conspicuously transversely folded and with rather distinct dorso-lateral lengthwise ridges. The integument is closely set with minute spicules which are often soot-black. The posterior respiratory process is very short and deeply recessed in the fleshy folds of the last segment (Fig. 40). From above, the tubes appear diverging. The posterior spiracles (Fig. 45) are raised on high polished carinae and give to the posterior spiracular plate a narrow, angular appearance. The dorsal spur of the spiracular plate is short but sharply pointed.

The spiracles in this genus are characterized by a perforated chitinous plate situated just below the spiracular rim (Fig. 41) comparable to the fringe of chitinous bars in *Syrphus.* It is readily visible, even in uncleared specimens, under the high power of the microscope. Fluke (1929) says of these, in his discussion of *Metasyrphus wiedemanni,* "It is possible that these bars are for protection to the trachea from foreign matter but they may also serve as bars for rigidity of the spiracles, internal apophyses which hold the spiracular slits open."

The rectal gills are alike in all species, a pair of double finger-like structures joined at the base, on each side of the rectum, as in *Syrphus.* In Fig. 48 they have been shown extended.

KEY TO SPECIES OF METASYRPHUS

With elaborately convoluted posterior spiracles (Fig. 42)............... *nitens* (?)
Posterior spiracles simple slits (Fig. 47).................................... 1

1. Posterior spiracles II and III much closer together than I and II; the angle between I and II about twice as great as that between II and III (Figs. 43, 44).. 2

   Posterior spiracles II and III not much closer together than I and II; the angle between I and II only slightly greater than between II and III (Fig. 49).. 3

2. Small species, under 10 mm., color pattern remarkably like bird excrement .... *canadensis*
   Large species, 12-15 mm., light greenish with numerous brown fat bodies.. *meadii*
3. Posterior spiracles I projecting laterally so that the distance between their outer ends is greater than that between the outer ends of posterior spiracles II; large (12-15 mm.), light tan or grey-tan larvae; no isolated patches of black setae (Fig. 47) .... *perplexus*
   Distance between the outer ends of spiracles I no greater than that between the outer ends of spiracles II (Figs. 45, 49) 4
4. Vivid green, red and white, or green, pink, and white larvae; no prominent circular patches of very densely set black setae (Fig. 49) .... *vinelandi*
   Brown and tan or brown and grey diagonally patterned larvae with evident circular patches of densely set black setae (Figs. 40, 45) .... *wiedemanni*

Metasyrphus wiedemanni (Johnson)

The brown, diagonally patterned larvae of *Metasyrphus wiedemanni* (Fig. 40) are among the most widely distributed and most common of all the syrphid species. With the exception of *Sphaerophoria cylindrica* only, in this region, it surpasses all other species in value as a destroyer of aphids. Curran (1920) made a study of the numbers of aphids consumed by larvae of different abundant syrphid species. He found that *Metasyrphus wiedemanni* larvae consumed an average of twice as many aphids per day as any other species, but since their larval life is shorter than that of *Sphaerophoria cylindrica,* the latter larvae totaled more aphids per larva in their lifetime than *Metasyrphus wiedemanni.* The larva of this species is not only a voracious, but a very general feeder.

The immature stages were described by Metcalf (1912a) and figured in detail. In 1913b and 1916 briefer accounts were given by the same author. Jones (1922) described the stages of this species in Colorado and gave colored figures of the larva, puparium, and adult. Fluke (1929) gave a brief description of the larva, with particular reference to the posterior respiratory process and figured the posterior spiracular plates.

Larva (Fig. 40).—Length, 11-13 mm., width, 2.5 mm., height, 2.5 mm. The general effect is that of a knotty, wrinkled, brownish or greyish maggot with wedge-shaped tan marks down its back bordered by black diagonals, and on each side, a narrow lateral line of tan along the dorso-lateral carina. In detail the color pattern is as follows: the dorsal blood vessel is black or brown, interrupted by four whitish or deep flesh-colored transverse bars on segments 6 to 10. Lateral to it are slender dorsal lines of muddy white, tan, or pinkish globules which widen out into wedge-shaped chevrons of the same dull white or tan. Between these are black, prominent arrows, accentuated by surface vestiture of dark spinules. Running along the top of the dorso-lateral carina is a dull white or tan, somewhat undulating, lateral stripe. The sides are always translucent

grey. The actual colors may vary somewhat, but the brown diagonal pattern is always visible. When young, the larva tends to be strongly yellowish and very spiny.

The integument is closely set with microscopic black spinules, giving the whole surface a sooty appearance. In this species, especially, there are small lateral segmental patches of more densely set, black spinules with large, dark bases, usually located opposite the end of each dark arrow. The segmental spines (Fig. 46) are slender, two-segmented, light colored, and inconspicuous; the distal segment is about six to eight times as long as it is wide at the base.

The posterior respiratory process (Fig. 45) is red-brown and about as long as it is high. The posterior spiracles are slender, somewhat crooked slits on high, polished carinae, the median spiracle on each side somewhat nearer to the ventral than to the dorsal one. The ventral spiracles are usually almost parallel, but vary somewhat with individuals; in some they are slightly convergent at the tips. There is a sharp, but not high, dorsal spur on each posterior spiracular plate, projecting slightly higher than the highest spiracular carina. The interspiracular nodules are quite small and inconspicuous, and located near the proximal ends of the spiracles.

The species with which it is most likely to be confused is *perplexus,* and for the differentiation of the two species Fluke gives the following: *M. wiedemanni* larvae only 11 mm. in length, *M. perplexus,* 14-16 mm.; segmental spines light colored in *M. wiedemanni,* dark, almost black in *M. perplexus;* the interspiracular nodules are nearer the mesal ends of the spiracles in *M. perplexus,* and the lower spiracles incline to the midline of the organ with an angle of 2° in *M. perplexus* and an angle of 13° in *M. wiedemanni.* The last differentiation does not seem constant enough to the writer to be of value in differentiating the two species.

Recognition Characters.—1. Moderate-sized, greyish or brownish chevroned larvae (10-12 mm.). 2. Posterior spiracular plates not wider at level of outer tips of upper spiracles than at level of the outer tips of the second spiracles (Fig. 45). 3. Circular patches of enlarged black spinules in definite segmental positions (Fig. 40). 4. Segmental spines pale.

Puparium.—Length, 6.5-7.5 mm., width, 2.5-3 mm., height, 2.5 mm. The puparium is generally slenderer and trimmer than the plump type of *Syrphus* puparia; it is not strongly elevated posteriorly. The color is from light golden to rich chocolate-brown, always with a light feathering of black bars, produced by the concentration of integumental spines, and with dense, rounded spots on the dorso-lateral curvature. These are very rarely missing.

Food Habits.—The larva of this species was taken on nearly every common species of aphid: *Aphis gossypii* on muskmelon and cucumber,

Aphis spiraecola on spirea and Japanese almond, *Aphis helianthi* on *Cornus*, *Aphis oestlundi* on evening primrose, *Aphis cardui* on thistle, *Aphis rumicis* on curly dock, *Aphis brassicae* on cabbage and rape, *Aphis sambuci* Linn. on elderberry, *Periphyllus negundinis* on box-elder, *Eriosoma lanigerum* (Hausmann) on apple, *Georgiaphis ulmi* on slippery elm, *Macrosiphum rudbeckiae* on golden-glow, *Macrosiphum sanborni* on chrysanthemum, *Rhopalosiphum pseudobrassicae* on turnip, *Myzocallis alhambra* on oak, and *Amphorophora cosmopolitana* on wild lettuce. Metcalf (1913b) records it on *Siphocoryne avenae*, the European grain aphid, on apple and on *Melanoxanthus salicti* on black willow, as well as an unknown aphid from *Phragmites*, a reed. Jones (1922) reports in addition *Clavigerus smithiae* (probably from willow) and *Macrosiphum pisi*. Curran (1920) gives a long list with *Aphis pomi* and *Myzus cerasi* in addition to those mentioned above.

Metasyrphus vinelandi (Curran)

The larva and puparium of *Metasyrphus vinelandi* were described by Metcalf (1913b) as an unusual variety of *Metasyrphus wiedemanni*, since the adults he reared came within his conception of that species (at that time under the name of *Syrphus americanus*). Curran, later, at Vineland, Ontario, described the adult of this striking larva as *vinelandi* (1921).

This larva is not so common as that of *Metasyrphus wiedemanni* but it is by no means rare. In the situations where it is found, as in the flower spikes of *Rumex*, in spite of its brilliant colors, it blends surprisingly well with the surroundings, so that it often escapes the eye entirely.

Larva.—Length, 10-15 mm., width, 3 mm., height, 3 mm. A very beautiful and striking larva with a color pattern as follows: lateral third of dorsum and sides, clear grass-green; on each side are chevrons of bright pink or red, shading to soft white or dull pink laterally; on the tubercles of the sixth to tenth segments are four white transverse bars, interrupting pinkish to deep rose dorsal lines. The arrows are narrow and black; the dorsal blood vessel is slender and black, interrupted into segments.

The whole dorsum is closely beset with colorless to brownish sharp slender spinules, the darker ones on the more exposed folds. The conspicuous segmental spines (Fig. 46) are very dusky or brown, usually darker than the body vestiture. Frequently only the terminal segment of the spines is fuscous. The dense patches of dark, larger spinules, so characteristic of *Metasyrphus wiedemanni*, are lacking in this species.

The writer is unable to find any constant feature of the posterior respiratory process (Fig. 49) which differentiates it from that of *Metasyrphus wiedemanni*.

Recognition Characters.—1. Bright green, red, white, and black color pattern. 2. Segmental spines fuscous. 3. No patches of dense, black-based larger setae.

Puparium.—Length, 6.5 mm., width, 3 mm., height, 3 mm. Metcalf (1913b) points out that the puparium is much broader and higher than that of *Metasyrphus wiedemanni.* In the latter, the ratio of length to height is 2.6:1, and of length to width, 2.5:1; while in *Metasyrphus vinelandi* it is as low as 2.15:1 for length to height, and 2.03:1 for width to height.

Food Habits.—This species has been taken from early June to late in the year among *Aphis rumicis,* on *Rumex crispus,* among *Rhopalosiphum rhois* on sumac, among *Toxoptera graminum* (Rond.) on wheat, among *Aphis oestlundi* on evening primrose, among *Macrosiphum sanborni,* and among *Macrosiphum ambrosiae* on *Verbasina.* Metcalf (1913b) took this species in Ohio feeding on *Aphis brassicae* on various Cruciferae, on *Siphocoryne avenae* on apple, on *Melanoxanthus salicti* on black willow, and on colonies of aphids on *Phragmites.* It is, like *Metasyrphus wiedemanni,* an effective predator with a long season of abundance.

Metasyrphus perplexus (Osburn)

The larvae and puparia of this species have been described by Fluke (1929) and the posterior spiracular plates figured.

Larva.—Length, 14-16 mm., width, 3 mm., height, 3 mm. The larva is very large, robust, cylindrical and grub-like. The general effect is soft grey-tan, with creamy tan along the midline and two dim interrupted darker streaks running lengthwise along the body just dorsal to the lateral carinae. There is no particular pattern.

The segmental spines are sharp, short, and dark colored. The integument is covered with definite diagonal patches of short, large-based sooty black setae.

The posterior respiratory process is very short, even for this group, being slightly less than its height in length, and it is deeply recessed in fleshy body folds. The posterior spiracular plates (Fig. 47) have a curious "eared" appearance due to the fact that the upper spiracles are shifted downward and outward at their outer ends, making the carinae more prominent and giving the posterior spiracular plate a greater width at this point. In some specimens they are directly opposite one another on a single straight line. The dorsal spines are high and sharp; the groove between the plates deep. The interspiracular nodules are very minute. The lower two pairs of spiracles are long and wide. The spiracles are always straight and simple, not irregular as in *wiedemanni.*

Recognition Characters.—1. Very large larvae, 14-16 mm., usually soft

greyish tan with indefinite color pattern. 2. Posterior spiracular plates have eared appearance; width from tip to tip of outer angles of upper spiracles noticeably greater than width of rest of posterior spiracular plate (Fig. 47). 3. No marked circular patches of sooty spines, in definite segmental positions as in *wiedemanni*. 4. Segmental spines dark, almost black.

Puparium.—Length, 7.5-8 mm., width, 3.5 mm., height, 3.5 mm. The puparium is well rounded with the posterior end bent downward abruptly, and the tip curled under, exposing the posterior respiratory tube much more than in the larva (cf. *Lasiophthicus* and *Eupeodes*). The puparium is light golden brown with a series of six dusky, diagonal bars on each side of the dorsum, formed by the concentrated patches of sooty setae of the larva, but it has no lateral series of round black spots.

Food Habits.—The larvae of this species were taken among *Macrosiphum ambrosiae* on wild lettuce and *Verbasina* and among colonies of *Macrosiphum sanborni* on chrysanthemum. Fluke (1929) in Wisconsin took them commonly feeding on *Amphorophora rubicola* (Oest.) on wild raspberry. He took them rarely on *Macrosiphum pisi*.

The writer collected one very small newly-emerged adult specimen from a rearing cage in which were *Pachypsyllus celtoides* Riley galls. The leaves and galls were searched for a puparium to establish whether the syrphid had been feeding on the psyllid nymphs in the galls but none was found. It seems a matter of doubt whether even a small larva could develop in such a small space as the interior of these galls.

Metasyrphus meadii (Jones)

Metasyrphus meadii is, according to Fluke (1929), a typically western form, although specimens have been taken in Wisconsin, Ontario, and other eastern sections. Fluke points out that this species is the *Syrphus nitens* of western authors but not the *Syrphus nitens* described by Metcalf (1916) in which the posterior spiracles are highly convoluted. The account of Campbell and Davidson (1924) of *Syrphus nitens* which described the immature stages and food habits is presumably this species. The following descriptions have been taken from this paper. The figure was drawn from a puparium loaned by Dr. Fluke.

Larva.—Length, 12-15 mm., width, 3 mm. The body is laterally ridged. Observed closely, the color is greenish white, but the numerous, light brown fat bodies beneath the integument give a light brown color to the larva as a whole. The dorsal blood vessel is blackish.

The integument bears many areas of close-set blackish papillae, and the segmental spines are pale and rather short.

The posterior respiratory process (Fig. 44) is fuscous, its component tubes slightly divergent apically, each tube about as long as its basal

width. The arrangement of the posterior spiracles is different from any other species of *Metasyrphus* except *canadensis* and makes this species easy to recognize. Posterior spiracle II is much closer to posterior spiracle III than to posterior spiracle I, so that both, II and III point ventrally.

Recognition Characters.—1. Large, greenish-brown larva (12-15 mm.), typically a western form. 2. Posterior spiracle II much closer to III than to I; posterior spiracles II and III both point distinctly ventrad (Fig. 44).

Puparium.—Length, 7 mm., width, 3 mm., height, 2.75 mm. The puparium is light brown with numerous black parallel bars in groups of three, each three forming a diagonal stripe in the typical herring bone pattern. The dorsum of the puparium is broadly convex, and the venter slightly concave. The posterior respiratory process is dark brown, short, bearing spiracles in the position of those of the larva.

Food Habits.—Campbell and Davidson (1924) report this species from the following aphids in California: *Aphis avenae, Aphis gossypii, Aphis rumicis, Brevicoryne brassicae, Macrosiphum pisi, Macrosiphum cucurbitae, Macrosiphum rosae, Macrosiphum pelargonii, Myzus braggii, Myzus persicae, Myzus rosarum,* and *Thomasia salicola.*

Metasyrphus canadensis (Curran)

The larvae of this species have not been seen by the writer, but several reared specimens with puparia attached have been loaned by Dr. C. L. Fluke.

The larvae are quite small, about 8 mm. in length, and according to Fluke (1933), who has followed their complete metamorphosis in Wisconsin, strongly resemble the excrement of birds in their coloration. They feed on *Periphyllus populicola* (Thomas) on *Populus* spp.

Puparium.—Unusually small for this genus, measuring 5-5.5 mm. long, 2.5 mm. wide, and 2.76 mm. high. On the posterior part of the dorsum are at least four distinct transverse dusky bands, deeply emarginate behind or completely interrupted. In some specimens there is a distinct, tan, arcuate dorso-lateral line at the edge of these bands. The posterior spiracular plates (Fig. 43) are in proportion to the size of the larva and somewhat smaller than in other species. The position of the median pair of posterior spiracles approaches that of *meadii,* where the median spiracle is distinctly closer to the lower than to the upper spiracle. The carinae of the two lower pairs of spiracles are unusually low.

Metasyrphus sp. (*nitens* Zetterstedt?)

The larva and puparium of this species were first described and figured by Metcalf (1916) as *Syrphus nitens* Zett., but Fluke (1929) after a careful study of the adult in comparison with European material concluded

it was not the same as *Syrphus nitens* Zett. The larva of *Metasyrphus nitens,* as described by western authors, is very different from this larva also, having simple straight spiracles and is described under *Metasyrphus meadii.* Fluke referred this species then to *M. venablesi* but other reared specimens of *M. venablesi* are attached to puparia with simple slits, which cannot possibly be the same as the species of Metcalf.

The larva is an aberrant form for this group as evidenced by the elaborate sinuous posterior spiracles (Fig. 42). In all other respects, it clearly seems to belong in this genus.

Although this species was reared by Metcalf (1916) in Maine and is not known from Illinois, it is so unusual that it merits inclusion in this paper. The descriptions are taken from Metcalf's account.

Larva.—Length, 15 mm., width, 3 mm., height, 2.5 mm. An unusually slender, elongate species. The twelfth segment is nearly a third narrower than the rest and somewhat depressed, the posterior end squarish.

In their natural habitat, the larvae were so covered with threads of flocculence from the host aphid as to appear light grey in color. When this is removed the color is yellowish brown, considerably mottled with black. The most conspicuous black markings are due to masses of body fluids showing through the integument; but others are formed by particularly thick areas of the black integumental spines. There are nine such areas on each somite, three on the middle line and three at each side.

The entire dorsum is beset with minute, black integumental spines; the segmental spines are situated on moderate, conical elevations and are light in color.

The rectal gills, four finger-like processes arising ventrally from the caudal segment, are not, in Metcalf's figure, as symmetrical as the typical two double pairs of this group (Fig. 48). The writer believes them incompletely extruded but not in any way unusual.

The posterior spiracles are remarkably and irregularly sinuate (Fig. 42), each situated along the top of a broadly rounded carina. The interspiracular nodules are small, rounded, inconspicuous.

Puparium.—Length, 7.6 mm., width, 3.75 mm., height, 3.85 mm. Color greyish-brown, with a mid-dorsal, broken blackish line, and an oblique lateral black stripe on each side of the segment due to denser patches of integumental spines. The puparium is bulbous in front, a little broader than high. The ventral line is quite concave, the dorsal line well elevated, with the greatest height about mid-length. A prominent dorsal carina widening out anteriorly extends forward from the posterior respiratory process. The latter structure retains its larval characteristics.

Food Habits.—Metcalf collected this species on *Clavigerus flocculosa* Weed on willow in Maine.

THE EMARGINATUS GROUP ("METASYRPHUS")

The genus *Xanthogramma* is one whose adult characters have been rather poorly defined and whose borders have suffered alteration. In 1931 Fluke pointed out, in his paper "Notes on, Certain Syrphus Flies Related to *Xanthogramma* (Diptera, Syrphidae)," that the original characterization by Schiner limits the genus to one known species in North America, *Xanthogramma flavipes* Loew. He placed all the other species which had been ascribed to *Xanthogramma* in the genus *Syrphus.* In a later paper (1933) he removed this group to the genus *Metasyrphus* Matsumura and Adachi and treated them as a distinct sub-group, the *"emarginatus* group," but indicated that they warranted still further isolation from related forms. He suggested the genus *Olbiosyrphus* might possibly be used to include this group.

An examination of the larvae strongly bears out the advisability of including the *"emarginatus* group" in a genus of its own. The striking and beautiful body form makes them readily recognizable at a glance. They are strongly flattened dorso-ventrally, broadly ovate from above and fringed around the margin with deep serrations. They show no resemblance whatever to the cylindrical, compact, unornamented larva of *Xanthogramma flavipes* (Fig. 96), which may be taken as a typical representative of the genus. Another *Xanthogramma* similar in appearance to this larva has been figured by Vimmer (1933) from Czechoslovakia. The relatively long posterior respiratory process of the *emarginatus* group bears spiracles which are straight, simple slits on low carinae; the short, stump-like process of *Xanthogramma flavipes* bears spiracles which are tortuous loops flat on the surface of the spiracular plate. On the other hand, the *emarginatus* group larvae do not resemble those of *Syrphus* or *Metasyrphus* any more closely. Both of these genera have long, slender, tapering larvae which are subcircular in cross section; both have relatively short posterior respiratory processes and in *Syrphus* (but not *Metasyrphus*) the spiracles lack carinae.

The larval characters strongly point to the need for a new genus, but the writer feels that this move is already indicated, and that a new genus cannot be erected on the basis of larval characters. In this *genus innominatum* are included *Scaeva emarginata* Say which was later changed to *Xanthogramma emarginata* by Williston, *Syrphus weborgi* Fluke, *Xanthogramma divisa* Williston, and *Syrphus invigorus* Curran.

The species of this group, where the larvae are known, form a homogeneous group of distinctive, flattened, serrate-edged larvae whose extreme similarity makes them difficult to separate. Of the species whose larvae are known, *divisus* and *invigorus* can be distinguished from the others, but the writer is as yet unable to separate the immature stages of

"Metasyrphus" emarginatus from those of *"M." weborgi* with any certainty. Although the stages of *"Metasyrphus" weborgi* were described in detail by Metcalf (1917) and *emarginatus* by Fluke (1931), who gives tables of comparative measurements of the two larvae, whatever differences may be found in the two accounts fail when compared with the actual specimens. The same differences in average measurements between the two species can be found between individuals of the same species. It might be suspected that the two species were not distinct, if the adults were not very clearly distinct and sharply separated.

The larvae of the *emarginatus* group are rather sluggish and, on the plant where they are found, look somewhat like a blighted area or leaf scale. All the known larvae are aphidophagous. In captivity they feed readily and soon come to full size, but then, instead of pupariating, waste away in complete inactivity and finally, after weeks or months, die. However, if placed in a flower pot with grass and leaves and left out of doors in all kinds of weather, the larvae will pupariate normally and emerge as satisfactorily as other syrphid larvae. This peculiar reluctance to transform under ordinary laboratory conditions is so uniform that it may be called a physiological character of the *emarginatus* group. *Xanthogramma flavipes,* on the other hand, pupariates readily.

Larva of the "emarginatus" Group (Fig. 50).—Length, 7 mm. (*divisus* contracted) to 10.5 mm. (*emarginatus,* extended), width, 5-5.5 mm. Dorso-ventrally flattened; when at rest, a broad oval, narrower at the anterior end. When contracted, there are nine segments visible from above, the most anterior one of which is the fourth segment. The first three body segments are retracted under the sharp, spiny margin of the fourth segment, but in activity they are extended in a tapering cone similar to the anterior end of a typical syrphid larva. On the concealed third segment are found the minute anterior spiracular processes.

The lateral margins of the larva are continuously serrated with pointed lobes, three large subequal serrations and one small serration to each segment on segments five to eleven inclusive. The twelfth has only one large and one small lobe. Each of the large lobes bears a short segmental spine, but the small fourth lobe has none. The median dorsal and dorsolateral segmental spines are minute, pale, and inconspicuous but present on the dorsum in their normal positions. Each spine (Fig. 56) consists of a slender distal piece about four times as long as it is broad and pointed at the tip, on a short basal piece which is almost ball-like in its proportions and more than twice as broad as the distal spine. The whole fleshy lobe is ornamented with rings of coarse granules.

The integument of the larva is moderately wrinkled, delicate, glossy and transparent. It is without vestiture, but over the dorsum it is covered with minute papillation that grades imperceptibly into the coarse papillae

of the lateral lobes and of the truncated anterior and posterior edges. Since the skin is transparent, all color is due to that of subcutaneous fatty masses. These are collections of rather small and rounded globules in definite patterns but they are somewhat movable. Along the midline they pulsate with the heart movements.

The posterior respiratory process (Fig. 57) is always more than twice as long as it is broad at the tip. The two tubes are completely united in the basal half, so that no trace of a median groove is visible. This portion is roughened by coarse nodules. The distal half is grooved sagittally, above and below, by a shallow median groove and bears smaller papillae than the basal half. From above, the process tapers gradually from a broad base to about the midline, where there is always a fold, but it may be very inconspicuous. From here the sides are either parallel for a short distance or expand laterally at the tip. The ends of the tubes, when viewed from the side, slant down from above (*not* up, as stated in Fluke's description of *divisus*), so that from above most of the spiracular plate is visible. From the flat surface of each plate four, irregularly rugose interspiracular nodules protrude. The spiracles themselves are straight, simple slits on low carinae. The circular plates are large and well developed; their dorsal inner sector is bordered by a thickened rim which extends downward as a low ridge for a short distance beyond the ring (Fig. 54).

The rectal gills are peculiarly broad and flattened (Fig. 52).

"Metasyrphus" emarginatus (Say) and *"Metasyrphus" weborgi* (Fluke) = (*Xanthogramma divisa* Williston)

The egg and larva of *"M." emarginatus* have been described briefly and the puparium, posterior respiratory process, and spiracular plates figured by Fluke (1931). He also gives a table comparing the measurements of the various dimensions of the posterior respiratory process for *emarginatus, weborgi,* and *divisus*. A second table is given for the spiracular angles of these species. None of these careful measurements afford very satisfactory means of separating *emarginatus* from *weborgi*. In the Illinois region, however, *emarginatus* is by far the most abundant of the four known species of *"Metasyrphus."* The stages of *"M." weborgi,* which had not been named at that time, were described in detail and figured by Metcalf (1917) as *divisa* Williston.

Larva (Fig. 50).—Average length of mature larva, 10.5 mm., width from tip to tip of lateral lobes, 5-5.5 mm., height, 1.3 mm. The color pattern is made up of seven main oblique diagonal bands of buff, pinkish tan, or orange globules on each side of the midline. Where the globules are lacking, the color is a translucent brown or greenish grey. The diagonals meet opposite one another in a point and give the larva a distinctly chevroned appearance with the points of the chevrons directed forward.

Along the midline runs a longitudinal, segmentally fragmented, more opaque stripe. As the mature larva becomes dormant the color turns dull brown to ashy grey.

For details of body form and external structures, reference should be made to the foregoing general description. The posterior respiratory process (Fig. 57) arises from a broad base and tapers distally to a distinct midfold, from where it slightly expands to the spiracular plates. The interspiracular nodules are quite variable; in some specimens they are low and rugose, while in others they have irregular perpendicular lamellae arising from the surface.

In the tables of Fluke, the two species, *emarginatus* and *weborgi*, differ in measurements of the dimensions of the posterior respiratory process by only a few hundredths of a millimeter, a difference which is insufficient for satisfactory identification by this means. The angles of the posterior spiracles also correspond very closely. The angle at which spiracle III inclines to the midline is 23° in *emarginatus* and only 12° in *weborgi*. This difference would appear to the naked eye, as the two lower spiracles are slightly more convergent in *emarginatus* than in *weborgi*.

Puparium.—Length, 8 mm., width, 4 mm., height, 3 mm., at anterior end. The shape of the puparium is considerably different from that of the larva. The anterior end arches up in a strong convex curve, rounding in front and about as broad as the width of the posterior end of the body. At about the mid-point the dorsum curves sharply down, and it is almost concave just before it reaches the base of the posterior respiratory process. The sides are almost parallel and retain, on the curving lateral line, the shrivelled remnants of the lateral lobes of the larva (Fig. 51). The posterior respiratory process is similar to that of the larva.

Food Habits.—*"Metasyrphus" emarginatus:* on *Macrosiphum rudbeckiae* (Fitch) on wild golden-rod, on *Macrosiphum ambrosiae* on wild lettuce, on *Clavigerus smithiae* on willow, and on *Aphis gossypii* on Althea or Rose of Sharon. Fluke, in Wisconsin, also records this species from *Amphorophora rubicola* on wild raspberry.

"Metasyrphus" weborgi has not been reared by the writer to an adult but may be represented in the above collections. Metcalf (1917), in Maine, found it among *Clavigerus smithiae* on willow, and he also gives other records from Maine as on *Aphis cerasifoliae* Fitch on choke cherry, on *Aphis cornifoliae* on dogwood, and on *Chaitophorus populicola* on poplar.

"Metasyrphus" divisus (Williston)

The immature stages of *"Metasyrphus" divisus* are described in detail by Fluke (1931), and in the same paper the larva, the puparium, the posterior respiratory process from the side, and the posterior spiracular

plates are also figured. The following account is taken from his description, but the illustrations have been drawn from pupal material kindly loaned to the writer by Dr. Fluke. The *divisa* described by Metcalf has been referred by Dr. C. L. Fluke to the species *weborgi* Fluke and is discussed under that species.

Larva.—Length contracted, 7 mm., width, at the widest point, 4 mm. The larva presents all the morphological details mentioned in the general description.

The larva is described as being an unusually handsome syrphid. The color pattern is, briefly, a rich reddish tan chevron occupying the median half of the body, the two ends of the body yellow. The detailed description is as follows: A tan band which occupies the posterior half of the body, oblique in shape, pointed anteriorly on about the middle segment. On this segment the tan color occupies only the middle area or disc, and the sides are yellow. The following three segments are pink, the last of the three being only irregularly tan on the dorsum. The anterior three exposed segments are yellow, and the posterior two are also yellow.

The posterior respiratory process (Fig. 53) is longer and more slender than is usual in this group. When viewed from above, it is broad at the base, slopes evenly to the middle; the sides are then parallel for a short distance, widening very slightly just before the tip. When viewed from the sides, the tip of the tube slants down from above, the dorsal side being shorter. The measurements of the dorsal and ventral sides have been reversed in Fluke's description but, corrected, they are as follows: dorsal length, 0.744 mm., ventral length, 0.896 mm., height at tip, 0.193 mm. The spiracular plates (Fig. 54) are very small, only about three-quarters of the size of those of the other three species.

Recognition Characters.—1. Small larvae, 7-8 mm. long. 2. Predominant color yellow, with rosy-tan transverse band across the middle of the body. 3. Straight, slender, tapering posterior respiratory process, the tip smallest; each spiracular plate, not more than 0.2 mm. in diameter (about three-fourths the diameter of those of the other species) (Figs. 53, 54).

Puparium.—Length, 6 mm., width, slightly under 3 mm. The colors of the larva disappear completely; the puparium is light buff or straw color with irregular black crossbars on the third to the sixth segments; the eighth and ninth segments usually with small median black dots. The shape of the puparium is similar to that of the members of this genus. The features of the posterior respiratory process are the same as those of the larva.

Food Habits.—The larva of this species has been taken on *Chaitophorus populicola* on *Populus* spp. near Columbus and Madison, Wisconsin, by Dr. C. L. Fluke.

"Metasyrphus" invigorus (Curran)
(= *Syrphus felix* Fluke)

So far as known there is no previous account of the larva of this species. Fluke (1931) states only: "A careful study of the larva, pupa and posterior respiratory appendage shows very little, if any, difference between *felix* and *emarginatus.*"

Larva.—Length of mature larva, 10.5 mm., width, 4.5 mm. The general description of a larva of the *emarginatus* group applies to this larva. It is slightly more slender than *emarginatus* larvae.

The color pattern in the second and early third instar larvae consists of seven pale green diagonals of scattered subcutaneous fat granules on a translucent, brown background similar to those in *emarginatus.* Along the mid-dorsum runs a pair of green opaque stripes, constricted segmentally. In the late third instar, the median stripes become bright butter yellow, tinged laterally with paler yellow; the diagonals become golden tan to white and the intermediate spaces are light translucent brown. The general effect is warm golden buff.

The posterior respiratory process (Fig. 59) affords the only characters by which this species may be separated from *emarginatus.* When viewed from above, the posterior respiratory process arises from a broad base of the same width as that in *emarginatus,* tapers inward distally to about the middle fold where the sides are parallel or slightly convex, and in the distal fourth, flares abruptly outward again so that the tips are approximately as broad as the base. This somewhat dumbbell-like, symmetrical outline is especially evident from above. A line through spiracle II is at right angles to a line through centers of I and III, while in *emarginatus* the angle between I and II is distinctly larger than that between II and III (Figs. 55, 58). The interspiracular nodules are relatively larger than those of *emarginatus* and not so high as most in *emarginatus.*

Recognition Characters.—1. Fairly large larvae, 10.5 mm. in length, tends to be green or yellow in color. 2. Posterior respiratory appendage strongly flaring at outer end which is of about the same width as the base (Fig. 59). 3. Spiracle II at right angles to a line drawn through spiracles I and III (Fig. 55).

Puparium.—Length, 8 mm., width, 4 mm., greatest height, 3 mm. The puparium is marked in the usual manner for this group with four irregular, transverse blackish bands on the anterior half of the dorsum, with a median small dot of black on segments nine, ten, and eleven (Fig. 51). The puparium has the same flaring spiracles, when viewed from above, as found in the larva.

Food Habits.—The larva has been found among *Macrosiphum ambrosiae* on wild lettuce (*Lactuca* sp.) and on *Verbasina helianthoides,*

and among *Macrosiphum sanborni* on chrysanthemum. In comparison with *emarginatus,* it is never very abundant.

EPISTROPHE Walker

Epistrophe is a large genus, containing forty-eight species according to the recent revision by Dr. C. L. Fluke (1935). The genus, however, occurs more commonly in the far West than in the Middle West. As far as the writer knows, the two species here described are the only ones of which the larvae are known.

The larvae of this genus are aphidophagous and bear a strong resemblance to the larvae of a closely related group, the *emarginatus* group of *"Metasyrphus."* However, they can be distinguished from this group, which is the only other genus with which *Epistrophe* might be confused, by the following generic characters: the shape of the body is an elongate oblong, not a broadly ovate leaf-like form (Fig. 60); the lateral serrations are plumply rounded papillae on three slightly different levels, not flat plates on a single, sharp-edged plane; the posterior spiracular plates (Fig. 64) each bear four short, delicate, interspiracular setae, a character known elsewhere only in the genus *Pipiza;* there may be a strong spur at the inner dorsal angle of the posterior spiracular plate, which is not found in the *emarginatus* group.

KEY TO SPECIES OF EPISTROPHE

Brown and white lacy color pattern with median white chain-like marking; dorsal spur of posterior spiracular plate claw-like; circular plates nearly circular..*cinctus*

Anterior third bright tan, maroon, or black, posterior two-thirds chalky white, resembling a bird dropping; dorsal spur an elongate ridge, not a sharp claw; circular plates elongate dorso-ventrad, irregular in outline..*triangulifer*

Epistrophe cinctus (Fallén)

The larva of this species is one of the most beautiful syrphid larvae the writer has seen. Eight larvae were found in the Wabash River valley, near Lafayette, Indiana, in the tightly curled leaves of elm infested with *Georgiaphis ulmi.* Collected on June 12, the larvae fed and reached maturity in about a week, then lapsed into a dormant state. Four were placed out of doors in a flowerpot; they remained in the larval stage until March 24, when one pupariated and emerged, an adult female, on April 4. The remainder either died or were killed by predaceous mites.

Larva (Fig. 60).—Length, 10.5-13 mm., width, 3-3.25 mm., height, 2-2.5 mm. Dorso-ventrally flattened, an elongate oblong from above, tapering gradually at the anterior end. The margin is serrated with lobe-like projections in groups of three of different sizes, the largest one slightly above and caudad to the smaller two. Each projection bears a

segmental spine (Fig. 63). These spines are minute, pale, and consist of a stout basal segment, somewhat longer than broad, surmounted by an acuminate distal segment, subequal in length to the basal one. The integument is without vestiture, delicate and finely papillose.

The general color effect is that of a lacy pattern of white, rich red-brown, and black. The colors are due, as in many other groups, to subcutaneous visceral globules. The dorsal blood vessel is separated into a chain of five, sometimes six, black oval dots (Fig. 60). Around all but the last is a keyhole-like ring of white. The margins of the lateral lobes are white and this is extended forward in diagonal bars. Between the white regions are irregular mottled areas of white, rich pink, or orange on a background of translucent dark brown. Just within the white diagonal bars is a region of deeper brown.

The posterior respiratory process (Fig. 61) is 0.7-0.8 mm. in length; about two-thirds the distance from the base is a permanent fold. Up to this point the tubes are completely fused and covered with coarse nodules; the smooth, polished distal third is less completely fused. The two tubes of this portion are separated by a groove and a deep median incision. The spiracular plates (Fig. 64) bear four delicate short interspiracular setae, each less than half the length of the spiracles. The spiracles are curved, simple slits borne on well developed carinae. At the dorsal, inner angle of each spiracular plate is a strong, claw-like spur which varies somewhat in length. The point of the spur curves outward and is hollow at its base; the base partially surrounds the circular plates which are tilted up at an angle from the surface of the posterior spiracular plate.

Puparium (Figs. 66, 68).—Length, 8 mm., height at anterior end, 2.5 mm., width, 2.5 mm. Strongly arched anteriorly, but very narrow, so that the lateral margins, when viewed from above are nearly parallel. The whole puparium has a curiously attenuated, hump-backed appearance. There is a broad ridge on the posterior two-thirds. The prominent lateral serrations of the larva have shrunken to oblique corrugations and irregular lateral tags.

The color is light brown. Since this larva pupariates in the soil, the puparium is more or less covered with earth. On the anterior third of the dorsum is an elaborate and symmetrical pattern of black spots. At the highest point of the arched region is a short, median stripe surrounded by a regular group of six smaller spots; posterior to this is a broad, gracefully shaped spot with two scroll-like arms anteriorly and a slender, posterior stem.

The characters of the posterior respiratory process are the same as those of the larva (Figs. 61, 64).

Food Habits.—This species was reared from *Georgiaphis ulmi* on slippery elm (*Ulmus fulva*).

Epistrophe triangulifer Zetterstedt

The larvae of this species were first described and figured by Metcalf (1917) under the name of *Syrphus oronoensis.* In 1922, Jones gave a colored illustration of a larva and puparium as *Syrphus triangulifer* (?) but gave no description. The figure may possibly be of this species.

The writer has not reared this species. The descriptions below are taken from Metcalf (1917), but the figures were drawn from material loaned by Dr. Metcalf.

Larva.—Length, about 11 mm., width, 2.5-3.5 mm., height, 1.5-2.5 mm. The larva is elongate in outline, flattened, subtriangular in cross sections. It resembles in all gross details those of *E. cinctus.*

Conspicuously colored, the posterior two-thirds is chalky white, except along the margins; the anterior third, the entire lateral margins and the terminal segments are bright tan, maroon, or even black. This sharp contrast gives to the larva an appearance suggestive of a bird-dropping. The chalky white median line of adipose tissue ends abruptly between segments 6 and 7 where the body is always quite blackish in larvae of all stages. On the anterior part of segment 7, the white adipose mass begins again, quite as abruptly, with two U-shaped loops opening caudad and separated by the black heart line.

The brown posterior respiratory process (Fig. 83) resembles that of *cinctus,* in length, distal constriction and surface texture but the spiracular plates are different. The black dorsal spiracular spur is elongate dorso-ventrad and ridge-like, somewhat crescent-shaped, bending laterally over the circular plate. The latter is elongate dorso-ventrad and narrower at the ventral end (Fig. 60).

Puparium.—Length, 7 mm. or more, width, 3.25 mm., height, 2.75 mm. The anterior half is irregularly globose, the puparium somewhat suddenly depressed about mid-length, the posterior half remaining flattened, much as in the larva. The predominating color of the puparium is maroon to black, extensively mottled with patches of white or pinkish brown. The writer believes this to be the color in newly transformed puparia but, from the colors of empty puparia, believes the puparium in later stages more closely approaches the colors given for *cinctus.*

Food Habits.—Metcalf in Maine (1917) records the larvae from *Pterocomma smithiae* Monell on willow, *Myzus cerasi* on cherry and on *Phorodon humuli* Schrank and *Rhopalosiphum nymphae* (Linn.) on plum. Jones (1922) reared this species from *Chaitophorus populifolii* Oestlundi.

Pipiza Fallén

The larvae of *Pipiza* are all small to medium-sized larvae, 5-12 mm. long, when mature. They are deeply wrinkled, ventrally flattened, dor-

sally convex and a long oval in outline, tapering at both ends, with a conspicuous, slender, stem-like posterior respiratory process. There are one or more pairs of short, blunt, fleshy lobes on each side of the last segment (Figs. 69, 72).

The color of *Pipiza* larvae is usually somewhat drab and indefinite and masked by the grey, waxy secretion of the aphids on which they feed. The larva of *Pipiza pisticoides* is yellowish, flesh color, or dun; the larva of *P. femoralis* is clear, light, translucent green fading to translucent mud-color.

In addition to the general appearance, which is sufficiently distinctive to permit recognition of the genus, the larvae of *Pipiza* have some characteristic microscopic characters. The posterior spiracular plates bear four strong interspiracular setae always more than half as long as the spiracles; there are no dorsal spines between the spiracular plates (Fig. 70).

The larvae of *Pipiza* are aphidophagous and seem to prefer as hosts those colonies of aphids which secrete a waxy flocculation. *P. pisticoides* has been reared from colonies of *Eriosoma lanigerum* (Haus.), the woolly apple aphid, both above and below the ground. Walsh (1869) reared *P. radicum* from the root-infesting colonies of the same aphid. *P. femoralis* has been reared by the writer from colonies of *Georgiaphis ulmi*, an aphid of slippery elm, which produces flocculent white masses, and Metcalf (1913) reared it from *Colopha ulmicola* (Fitch) the coxcomb gall of elm which also secretes a waxy dust. The author has also some specimens of an unknown *Pipiza* from Rhode Island collected by Mr. John D. Crawford on *Prociphilus tessellata* (Fitch) which is also a woolly aphid, on alder. It seems rather remarkable that all the known species of *Pipiza* should prefer so uniformly aphids with waxy secretions. The habit undoubtedly affords them considerable protection; buried among the waxy masses of their hosts and dusted with the same material, it is very difficult to detect the syrphid among the colony of aphids.

KEY TO SPECIES OF PIPIZA

Larger larvae (9-11 mm.), usually greenish in color with one pair of fleshy papillae extending back from the posterior segment; posterior spiracular plate more angular with oval circular plates; segmental spines with distal segment placed eccentrically on basal segment (Figs. 69, 71, 76) . *femoralis*

Smaller larvae (6-8 mm.), usually yellowish or dun or dull flesh color, with more than one pair of fleshy papillae on posterior segment 1

1. With two pairs of lateral, blunt, fleshy papillae on posterior segment; posterior spiracular plate compact, rounded, not angular, with circular plates perfectly circular; segmental spines not eccentric (Figs. 70, 72, 73) .... *pistacoides*

With three pairs of lateral fleshy papillae on posterior segments....... *radicum*

Pipiza pisticoides Williston

The larva and puparium of *Pipiza pisticoides* have been described and illustrated by Metcalf (1916).

Larva (Fig. 72).—Length, 9 mm., width, 2 mm., height, 1.75 mm. The color of the larva varies from pale straw yellow or flesh color to dull tan and is masked by grey waxy bloom. It is transversely wrinkled and, even though heavily dusted with wax, appears bare to the naked eye. The entire integument is densely covered with very short pale thorn-like setae. It is of the typical shape of the genus, though somewhat slender and tapering at both ends. The last segment, when viewed from above, bears two blunt fleshy lobes on each side of the posterior respiratory process. The segmental spines are composed of two subequal segments, the terminal segment arising from the center of the broad basal one (Fig. 73).

The posterior respiratory process (Fig. 70) is constricted slightly at its mid-point; distad of the construction it is polished brown, proximad it is fleshy, beset with spines and the same color as the body of the larva. The process is about three times as long as its width. The spiracles are raised on moderate carinae and on either side of each spiracle is a short, strong bristle; in all, four pairs.

Puparium.—Length, 5 mm., width, 2 mm., height, 1.8 mm. Color, dull dust brown to ashy grey. Strongly convex dorsally and somewhat concave on the ventral surface. The vestiture of the skin is not visible to the naked eye but gives a rough, felted appearance to the surface when magnified. The two pairs of fleshy lobes of the anal segment remain after pupariation as distinct lateral nodules, and the characters of the spiracular plates are the same as those of the larva. The shrunken and distorted segmental spines, however, are not sufficiently distinct to be of value in distinguishing the puparia.

Food Habits.—The larvae of *Pipiza pisticoides* have been taken, so far as is known, on *Eriosoma lanigerum* (Haus.) only. They have been taken both in the colonies infesting roots and in those in the old pruning scars of apple trees.

Pipiza femoralis Loew

This larva has been described as the "cock's-comb-gall syrphus fly" by Metcalf (1913b) who describes the larva, and figures the anterior and posterior ends of the larva and the posterior spiracular plates. He did not succeed in getting it to pupariate.

Larva (Fig. 69).—Length, 11 mm., width, 2.5 mm., height, 2 mm. It is a deeply wrinkled larva, apparently bare, although the dorsum is actually covered with closely-set, pale, integumental setae. The color of the larva is clear, pale, lettuce-green. Metcalf describes his cock's-comb-gall syrphid larva as vinaceous pink or purplish. Both the color and the vestiture are obscured by a dense powdery bloom from the aphids. No dorsal blood vessel is visible, but the black or yellow abdominal contents sometimes show through the delicate integument. When the larva ceases feeding for pupariation, it becomes more and more brownish, and, at last, dull translucent mud-brown. The posterior spiracles are rich brown.

The larva tapers gently at both ends. Segments 6-11 are of nearly the same width, the fifth and anterior segments tapering to a sharp point; the twelfth segment again is narrower than those preceding it. The mouth parts are of the usual aphidophagous type with two heavy lateral mouthhooks. Two delicate antennae are visible from above on the first segment. The anterior respiratory processes are rose or brown and unusually large and prominent.

Each segment bears twelve inconspicuous segmental spines, each two-segmented, bearing on a broad basal segment a slender acuminate terminal segment. The two segments are of varying proportions on different regions of the body, but in every spine the slender distal portion is more anterior than the axis of the basal portion, giving the entire spine an eccentric or offset appearance. At the posterior end of the larva, a single blunt fleshy process from the twelfth segment extends caudad, parallel to the posterior respiratory process. Although the anterior spine-bearing papilla of *P. pisticoides* is represented in *femoralis* by a spine, the papilla is reduced or wanting.

The respiratory process is 0.75-0.8 mm. long and about three times as long as broad. The two tubes are fused completely for their entire length except for a deep median incision between the posterior spiracular plates. The whole process is hardened and darkly colored and bears on the proximal half a number of small sharp papillae. The spiracular carinae are much higher than those of *pisticoides*, and protrude over the edge of the plate, giving it an angular outline (Fig. 71). Four strong setae, about three-fourths as long as the spiracles are found, one on each side of a spiracle. The circular plates are prominent, and are dorso-ventrally oval in shape. Above the circular plates are two or more rough nodules, the only irregularities on the smooth angular plates. The rectal gills are simple and finger-like, two pairs of two.

Puparium (Fig. 67).—Length, 8 mm., width at broadest point, 3 mm.,

height, 2.5 mm. Color, dull opaque mud-brown to ashy grey; strongly convex with hollow ventral surface. The vestiture is raised on end by the contraction of the integument and gives a rough felted appearance obscured by dirt particles. Remnants of the deep segmental wrinkles are still prominent at the posterior end of the puparium; the anal lobes are much contracted and reduced. The characters of the posterior respiratory process and larger size serve to distinguish this species from other known members of the genus.

Food Habits.—The larvae have been taken on *Georgiaphis ulmi* on slippery elm (*Ulmus fulva*) and, by Metcalf, on *Colopha ulmicola* (Fitch), the cock's-comb-gall aphid of elm.

Pipiza radicum Walsh and Riley

The larva and puparium of *Pipiza radicum* were described by Walsh (1869) more than sixty-five years ago, accompanied by a small crude sketch of these and the adult. The description does not serve to distinguish this species from the more recently described species of the genus. The figure, however, shows that the larva, and possibly the puparium, has three pairs of fleshy lobes on the posterior segment. This may serve as a distinguishing feature.

Walsh's description is quoted as follows:

"Larva: Dull, pale, flesh color, tinged with yellow. Attenuated and somewhat depressed anteriorly; more blunt posteriorly, the anal segment being furnished with an elevated tube which is of a light polished brown at extremity. Wrinkled transversely, with a prominent fold at anterior and posterior edge of each segment. The larger segments well defined, the smaller ones less so. First segment thoroughly retractile, and sufficiently translucent when extended to show the dark triple-jointed mouth. A few soft, fleshy spines, of the same color as the body, and especially distinct on the anal segments. Generally covered and disguised by the soil which it inhabits. Length when extended, 0.23 inch (6 mm.). Described from two specimens taken in 1866 and three in 1868.

"Pupa: Dull, dirty yellow. Gradually formed by contraction of the larva, during which time the wrinkles are obliterated, and at last becomes quite smooth. Length, 0.18 inch (4 mm.)." Walsh also describes the creeping of the puparia of *Pipiza radicum* which, after being buried in moist sand, crawled up out of it to a distance of two inches.

Food Habits.—Predaceous on *Eriosoma lanigerum*, the woolly apple aphid, on the roots of apple, according to Walsh (1896).

PARAGUS Latreille

The mature larvae of the genus *Paragus* are very small, never over 10 mm. long, and even to the naked eye, markedly spiny.

There are three species in the United States, *Paragus angustifrons, P. bicolor,* and *P. tibialis.* The first species is doubted by some authors to exist at all and accepted by others on the basis of differences in the male genitalia from those of *tibialis* with which it is confused. The present writer has never reared any adults of *P. angustifrons* nor seen any larvae sufficiently distinct from those of *tibialis* and *bicolor* to be possible larvae of this species. Only one specimen of *angustifrons,* a male, has been taken in the field. It is probably rare in Illinois. The writer has seen no account of the larva in the literature.

So far as known, *Paragus* is entirely aphidophagous; the two species, *bicolor* and *tibialis,* are fairly common as red-brown, longitudinally banded or pearly white, minute larvae, inconspicuous among the axils of aphid-infested flower-heads of evening primrose, curly dock, and iron-weed or among the young leaf buds of milkweed from July to September. *P. bicolor* is not so common as *tibialis* and is most abundant somewhat earlier in the season.

KEY TO SPECIES OF PARAGUS

Posterior respiratory process broader than long; segmental spines awl-shaped; body form broad, somewhat flattened (Figs. 74, 78, 81) .... *bicolor*

Posterior respiratory process longer than broad; segmental spines blunt, peg-like; body form slender, tapering gently at both ends (Figs. 75, 79, 82) . *tibialis*

Paragus bicolor Fabricius

The larva and puparium of *Paragus bicolor* has been described in detail and figured by Metcalf (1911b) and a briefer description has been given in "The Syrphidae of Ohio" (1913b). The larva is also described by Jones (1922) and mentioned briefly by Campbell and Davidson (1924).

Larva (Fig. 78).—The mature larva is from 7-8 mm. long, 2.5 mm. wide and 1.8 mm. high; it is conspicuously flattened dorso-ventrally. The color is quite variable. The whole larva may be dun or translucent yellowish without any visible pattern but the pulsating dorsal blood vessel. Or, it may be a white-margined larva with a broad chestnut band running longitudinally down the dorsum. The band may fade out to pale rose or to a scattered collection of dull orange dots.

The segmental spines are raised on fleshy processes. The distal segment of each is a pointed awl-shaped spine as long as the raised process, and in this species it is directed caudad on each segment (Fig. 81). The whole surface of the skin is covered with fine bead-like papillation and completely bare of vestiture.

The posterior respiratory process is broader than long and deep brown in color. Its spiracles are raised on high carinae and the dorsal spur is large and sharp (Fig. 74).

The rectal gills are simple, two-branched, Y-shaped structures as in other aphidophagous syrphids.

Puparium.—The larva usually pupariates upon the plant, among the flower spikes or under the leaves. Length, 5.5 mm., width, 2.5 mm., height, 2.2 mm. Pale to medium brown and a long nearly perfect oval from above. The remnants of the pointed larval segmental spines cover it with scattered spines. The posterior respiratory process resembles that of the larva.

Food Habits.—The larva has been taken on *Aphis rumicis* on curly dock (*Rumex crispus*), sour dock (*Rumex obtusifolius*) and burdock (*Arctium minus*), and on *Aphis gossypii* on cucumber. Jones (1922) records it from *Aphis avenae* and *Aphis helianthi.* He also reared it in the laboratory successfully on *Aphis pomi, Aphis carbocolor,* and *Periphyllus negundinis.*

Paragus tibialis Fallén

The larva and puparium of *Paragus tibialis* were described fully by Metcalf (1911b) and redescribed briefly in "The Syrphidae of Ohio" (1913b). Campbell and Davidson (1924) give a brief description and a drawing of the larva, which does not show much structural detail.

Larva (Fig. 79).—The mature larva of *Paragus tibialis* is slightly smaller than that of *P. bicolor,* averaging 6-7 mm. long, 2 mm. wide, and 1.8 mm. high. The color is even more variable. It may range from pure, translucent pearly-white without any markings whatever to a beautiful, rich red-brown, banded form, the broad, median brick-red band edged with black and flanked by yellow lateral regions. There are all gradations between these: yellowish white larvae with two lateral, brown streaks on the anterior third, larvae with the two anterior brown streaks enclosing a faint pink mottling, pinkish white larvae with a broad orange-dotted band, dun-colored larvae with a brown, broad, median band. There is a distinct, but delicate, dorsal blood vessel.

The larva is more slender, spindle-shaped and not as flattened as that of *bicolor.* The integument, like that of *bicolor* is bare with a beady surface. The segmental spines are also raised on a fleshy projection, but are not quite so long as those of *bicolor.* The outer segment is a short blunt peg only about one-third as long as the entire process, and not directed backward except on the last three body segments (Fig. 79).

The brown posterior respiratory process is longer than broad and bears spiracles raised on high carinae and a sharp dorsal spur (Fig. 75). The rectal gills are similar to those in *bicolor.*

Puparium (Fig. 77).—Length, 5 mm., width, 2.5 mm., height, 2.5 mm. The color varies from light yellow to deep, dull brown. The form is more plumply stream-lined than that of *P. bicolor* and can be readily distinguished by its round tear-drop shape. The character of a posterior respiratory process which is longer than broad, is also present in the puparium.

Food Habits.—The larvae of *P. tibialis* have been taken among colonies of *Aphis rumicis* on curly dock, *Aphis vernoniae* Thomas on iron weed (*Vernonia baldwini*), *Aphis coreopsidis* Thomas on Spanish needle, *Aphis oestlundi* on evening primrose, *Aphis gossypii* on cucumber, and on *Myzocallis asclepiadis* Monell on common milkweed.

Metcalf (1913b) records this larva as taken from burdock preying on an unidentified aphid, and Campbell and Davidson (1924) in California report it from *Aphis gossypii* and *Aphis maidis.*

Didea Macquart

The larva of only one species of *Didea* has been so far described. This larva is found, in the Midwest, with the individuals of one characteristic host aphid on which it is predaceous, the large, mottled purplish-grey *Longistigma caryae* (Harris) on sycamore, late in September and October. Their very occurrence in the colony of these extraordinarily large aphids (one-fourth inch in diameter) and their own large size is so characteristic that it almost certainly serves to identify them as the larvae of *Didea.* Only one other larva, and a much smaller syrphid, *Syrphus torvus,* is known to attack this aphid. This fly is not very numerous in Illinois.

Didea fasciata Macquart var. *fuscipes* Loew

The larva and puparium of this species has been fully described by Metcalf (1911a), and again in 1913 in "The Syrphidae of Ohio" and more briefly in "The Syrphidae of Maine" (1916).

Larva (Fig. 84).—The fully matured larva of *Didea fasciata fuscipes* is 15 mm. long, 5-6 mm. wide at its broadest point, and 3.5 mm. high. It is broad, flattened, and blunt at the posterior end, and tapered scarcely at all at the anterior end. It has a very shaggy, spiny appearance, due to the fact that it is ornamented with segmental fleshy pointed lobes, some of which are accented in black and others in yellow, although its segmental spines are actually very weak and slender. The tough, wrinkled integument is closely set with sharp, black, short setae. At the tip of each fleshy process is a slender, weak spine, only about twice as long as the surrounding setae (Fig. 80). The ventral side is flat and completely bare of spinules.

The color of the larva conceals it admirably in the colony of grey, black-spotted host aphids. It is, in general, a mottled greyish fawn and deep brown, accented with black and yellow. The thin dorsal blood vessel, the tips of the median segmental lobes, the entire small dorsal lobes, and some irregular diagonal bands on the sides and dorsum are black. The bases of the median lobes, the dorso-ventral, lateral, and ventro-lateral lobes are tipped with bright yellow. The ventral sole is a broad band of translucent lavender, probably due to the internal contents colored by the purplish body juices of the aphids.

The large, short, disc-like posterior respiratory process (Fig. 83) is deep red-brown, with pale tan margins around the spiracular slits. The whole spiracular plate has a rough frilled appearance because the surfaces between the spiracles are raised in one or more undulating perpendicular lamellae, resulting in a corrugated surface much like that on the shell of a black walnut.

The rectal gills are four, arising in two simple pairs as in the genus *Syrphus.*

Puparium.—Length, 9-10 mm., width, 4.5 mm., height, 4.5 mm.; neatly rounded in front and nearly circular in cross section, tapering down to the posterior segment where it flattens out laterally. It is covered with conspicuous papilla-like prominences. The color is rich golden brown, dusky on the curved sides due to the investiture of black setae, and speckled down the length of the dorsum by four regular rows of black dots, the remnants of segmental lobes. The puparium can also be identified readily by two well preserved larval features: the weak, slender segmental spines and the short, disc-like, frilled, posterior spiracles.

Food Habits.—In Illinois, by the writer, and in Ohio, by Metcalf, *Didea fasciata fuscipes* has been taken only among colonies of *Longistigma caryae* on sycamore and basswood. In Maine, however, Metcalf (1916) reported it as occurring at the last of July and first of August on *Plocamaphis flocculosa* (Weed), the willow grove plant louse.

BACCHA Fabricius

The larvae of *Baccha,* so far as known, are aphidophagous or feed on other Homoptera. Bhatia (1932) reared *Baccha pulchriformis* Austen in India from psyllid nymphs on the leaves of *Bombax malabaricum.*

Baccha clavata Fabricius

The larva of *Baccha clavata* has been very briefly described and figured by Campbell and Davidson (1924) but not sufficiently carefully to show its most characteristic features. The larva and puparium are

very crudely figured by J. R. Watson (1926) but not described. The puparium was described by Townsend (1897), but the description is inadequate for identification.

Larva (Fig. 85).—Length, 10-11 mm., width, 2.5 mm., height, 2.5 mm. The larva of *Baccha clavata* is a cylindrical, very beautiful larva with soft-tones, dull colors, and with very large, thick, segmental spines on high narrow folds of the integument, separated into distinct dorsal nodules.

The general effect is that of soft greenish-grey lateral regions with a broad, pink dorsal stripe accented on each side by broken narrow black edges. The dorsal nodules may be soft pink or opaque white. The colors of the dorsal band may vary from greyish white to pale brown.

The larva appears to the naked eye distinctly but sparsely spined, in contrast to the very spiny larvae of *Paragus* and *Didea.* The large segmental spines are two-segmented. The distal segment fusiform and about twice as long as the proximal segments (Fig. 89). The median spines of the posterior segment project back prominently over the posterior spiracular process. In addition to the dorsal and lateral rows of segmental spines, there are short ventral spines on the three segments behind the anterior spiracles. The surface of the skin is covered with a fine mass of very short, indistinct setae.

The posterior respiratory process (Figs. 87, 88, 90) is short, dark brown, smooth and polished and set rather deeply in the folds of the last segment. It is so truncated as to expose the spiracles to the ventral surface more than to the posterior surface as in other syrphid larvae. There is no dorsal spine but a smooth rounded surface. The rectal gills are a simple pair of two-branched gills similar to those in *Syrphus.*

Puparium (Figs. 86, 91).—Length, 5.5-6 mm., width, 2.5 mm., height, 2.5 mm. of a long oval shape. It often, though not always, retains a characteristic foliate pattern of light tan, outlined in deep brown. The constricted remnants of the light dorsal band of the larva are tan, the black border is retained as an undulating brown margin. In addition, the posterior spiracles are the same as those of the larva, and shrivelled remnants of the distinctive two-segmented spines can always be found on some part of the puparium.

Food Habits.—The larva has been taken on *Aphis gossypii* on muskmelon and cucumber, on *Aphis oestlundi* on evening primrose (*Oenothera biennis*), and on *Macrosiphum sanborni* on cultivated chrysanthemum. Campbell and Davidson (1924) record this species from *Aphis rumicis* and *A. medicaginis* Koch.

Baccha lugens Loew

J. R. Watson (1926), in connection with citrus insects in Florida, figures the larva, puparium, and adult of this species, but the drawings

are so sketchy as to give almost no characters for identification of the larva and puparium. There is no description. The drawing of the larva shows a broad bulge about one-third its length from the anterior end, and that of the puparium has a strong anterior swelling with an abrupt constriction beyond the middle. Nothing can be distinguished as to the spines or posterior spiracles.

In June, 1936, Mr. B.D. Burks of the Illinois Natural History Survey collected a puparium at Urbana, Illinois, and reared from it an adult of *Baccha lugens.* This puparium is curiously dilated anteriorly and agrees in general appearance with that figured by Watson. From this single specimen the description which follows has been made.

Puparium (Fig. 92).—Length, 5 mm., width, 2 mm., height, 2 mm. The rather delicate, light golden integument is strongly dilated anteriorly and from above appears smoothly clavate. In lateral view, however, the dilation drops posteriorly in an abrupt hump about mid-length, giving a unique outline to the puparium. There are no remnants whatever of the intersegmental spines of the larva which are probably quite small, judging from the smoothness of the integument. The posterior spiracular plates (Fig. 93) show a strong relationship to those of *Baccha clavata,* but do not slant ventrally quite so strongly as the plates of that species. As in *clavata* a dorsal spine is absent from the posterior spiracular plates. The two lower pairs of spiracles are crowded ventrally as in *clavata* but are more vertical in position than those of *clavata.*

Food Habits.—The food of this species in Illinois is not known, but it is probably aphidophagous. In Florida it is recorded from *Aphis spiraecola* Patch and *Aphis gossypii* Glover on citrus trees.

Chrysotoxum Meigen

The writer has not seen any specimen belonging to this genus but the structural characteristics given below point to the probability that the larva may be of the aphidophagous habit. The descriptions given below are taken from those of C. T. Greene (1923a). The larva was found under a stone in a moist situation. The species given below is taken rarely in Illinois.

Chrysotoxum pubescens Loew

Larva.—Length, 11 mm., width, 5 mm., nearly cylindrical. Opaque white, segmentation irregular with numerous transverse wrinkles. The cephalic end tapers very slightly. On the ventral surface are seven pairs of prolegs. The posterior respiratory process, located in the center of the caudal end is .5 mm. long, dark reddish to black, and the two tubes are separated by a longitudinal groove on the dorsal and ventral surfaces.

Puparium (Fig. 94).—Length, 8 mm., width, 4 mm., posterior respiratory process, 0.75 mm. Pale, dull, luteous yellow. The puparium is cylindrical, rather blunt on the cephalic end, gradually tapering down to the caudal end. The integument is microscopically rugose. There is no evidence of either anterior or pupal spiracles.

The posterior respiratory process (Fig. 95) is about as long as high. The spiracles are three sinuous slits on low, shining black carinae; the dorsal spur is a circular ridge which gives the appearance of a tube-like structure on the upper inner angle of the spiracular plate. The interspiracular nodules are triangular, raised, and have a finely granular surface.

The food habits are unknown.

XANTHOGRAMMA Schiner

Xanthogramma flavipes Loew

Vimmer (1933) figures crudely the empty puparium of a Czechoslovakian species of *Xanthogramma*. The outline of the puparium is very similar to that of *Xanthogramma flavipes*. He describes it briefly in his key (translated): "Bearers of posterior stigmata short, black-brown, shiny, pointing obliquely, ends rounded. Pupa pear-shaped, slightly constricted in the middle." He does not designate the species and gives no further details except a subsequent note: "Length, 7 mm., width, 3 mm."

The single specimen reared was found as a short-bodied, white, soft-skinned larva, on July 18th, lying on leaf mold at the immediate foot of a tall walnut tree in a woods near Urbana. The situation in which it was found gave no evidence of its food material. The larva was seeking a place for pupariation; it was inactive, with its mouth parts and anterior segments retracted; it transformed two days later and emerged on July 31. The morphologic characters show a somewhat intermediate condition between the aphidophagous and the saprophagous types. There is no evidence of pupal horns, but the posterior spiracles show the elaborate form so characteristic of saprophytic types.

Larva.—Length, 8 mm., width, 3.3 mm., height, 3 mm. Color, dull, opaque white. The larva is of a short sausage-like shape, nearly cylindrical and rounded fully at both ends. The exterior is almost without features; the integument smooth and without vestiture, the form extremely simple. Numerous parallel creases divide the surface into about 32 sub-equal annulets, usually three to each actual segment.

The antennae and mouth parts were invisible, the mouth opening minute and inconspicuous. The anterior spiracular processes are just visible as minute light brown cornicles near the anterior curve of the body.

Internally the mouth hooks are small and weak; there are low pharyngeal ridges of the type found in saprophagous larvae.

The posterior respiratory process (Fig. 97) is polished, shining red-brown, about as long as it is high at the tip. The two tubes are completely fused into a short truncate cone, broad at the base, somewhat narrower at the tip, and oval in cross section. The tip is smoothly rounded at the edges and bears on its face three pairs of tortuously looped spiracles, three pairs of minute interspiracular nodules and two small circular plates, near the mid-region, which are faintly granular on the surface. At the dorsal margin is a raised, V-shaped ridge with the point just above the circular plates and the two arms diverging laterally over the rounded surface of the plate, where they diminish and disappear.

Puparium (Fig. 96).—The puparium is almost the same in general shape and dimensions as described above for the larva. Color, light golden brown with brownish creases and with a silky sheen due to minute shagreen on the surface. The middle region of the puparium is slightly constricted. The ventral surface shows a slight concavity, and there is an inconspicuous hip-like ridge at the posterior end on the ventral third of each side.

Food Habits.—Nothing is known of the food habits of this larva. Vimmer (1933) says "In ant hills." It is probably saprophytic.

XYLOTA Meigen

One or more of the immature stages of several species of this genus are known. Johnson (1906) described briefly and figured the larva and puparium of *Xylota pigra.* The larvae of two unknown American species of *Xylota* are described by Johannsen (1935), but the rather rare immature stages of this genus have been most frequently taken as puparia and most descriptions of known species are of this stage. Greene (1923a) has described the puparia of *X. bicolor* and *X. pigra* and illustrated them in detail. These descriptions appear in a briefer form in Johannsen's "Aquatic Diptera, Part II" (1935).

Two pairs of dark, heavy, lateral hooks fused at their bases appear to be characteristic of this genus although Lundbeck (1916) describes an European species, *X. segnis,* in which the hooks are replaced by groups of small spines. The hooks are always located on the dorsal aspect of the false head in the larva and at the antero-ventral angle below the edge of the operculum in the puparium. The posterior respiratory process is usually only moderately long, from twice to about four times the width of the process, and there is always more or less of a lattice-like sculpturation present on its distal portion.

KEY TO SPECIES OF XYLOTA

Posterior respiratory process shorter, only about three times as long as height, with a marked constriction midway in length; plumose hairs at tip lacking (Fig. 98) .... *X. pigra*

Posterior respiratory process longer, at least four times as long as high, no marked constriction, plumose hairs present (Fig. 101) 1

1. Larger species (12 mm.) with two pairs of posterior lateral fleshy processes .... *X. bicolor*

   Smaller species (under 10 mm.) with three pairs of posterior lateral fleshy processes 2

2. Posterior respiratory process rugose for more than half its length distally; inner thorn short, blunt, and straight; outer thorn curved (Fig. 100); larger (8 mm.) .... *X. nemorum*

   Posterior respiratory process rugose for half or less than half its length; thorns subequal, both curved (Fig. 99); smaller (7 mm.) ...... *X. fraudulosa*

Xylota fraudulosa Loew

A puparium from which this description has been made, was collected by Mr. A. P. Arnason on a decayed log at Tiptonville, Tennessee. Adults of this species, collected in Illinois, are represented in the Illinois Natural History Survey collection.

Puparium (Fig. 101).—Length, 7 mm., width, 2.75 mm., height, 2 mm. The color is yellowish brown with overlying chaffy vestiture of a whitish color. The puparium is slightly flattened dorso-ventrally; it declines steeply in front, and is dorsally arched posteriorly giving a curiously mouse-like outline. On each side of the rather pointed antero-ventral margin, somewhat obscured by the chaffy vestiture, is a pair of subequal black, basally fused hooks or lateral thorns, both of which are curved (Fig. 99). They are situated just below the operculum and remain even if the operculum is lost. Mediad and just dorsad of these are the short brown, peg-like anterior spiracular processes on the lower piece of the operculum. On the dorsal piece of the operculum are the pupal respiratory horns which are yellow, curved, club-like and about three times as long as broad. On the distal portion of each are five double rows of more or less confluent tubercles, except for a narrow area on the inner anterior surface. On the ventral surface of the body, six paired groups of recurved hooklets can be plainly seen, the remnants of the prolegs; the seventh and most anterior pair is no longer discernible in the strong rugosity of the anterior end.

The posterior respiratory process is 1.25 mm. in length, light brown, slender, with a slightly bulb-like expansion just before the tip. The distal half, or a little less, is sculptured with lattice-like depressions. There are long plumose hairs present on the posterior spiracular plates, which resemble those illustrated for *Xylota nemorum* (Fig. 104).

Xylota nemorum Fabricius

The larvae and puparia of this introduced species were described by Lundbeck (1916) from Denmark, and his description of the larva has been used here; the figures were drawn from four puparia in the collection of the Illinois State Natural History Survey which were collected at White Heath, Illinois.

Larva.—Length, 9 mm. The color is yellow or whitish yellow. The body is elongated, arched above and a little flattened below; the head is broad and blunt; the posterior end is somewhat attenuated. The body is transversely corrugated and bears toward the end of the tapering posterior part at each side three lateral processes, clothed in relatively long hairs. On the ventral side are six pairs of prolegs armed with spines, and below the prothoracic segment is a pair of similar spined warts. At each side of the prothoracic segment outward from the brown anterior spiracles is a large black double hook, the outer hook being curved and larger.

The brown respiratory process is 0.7-1 mm. long. In this species the distal portion is clathrately sculptured for more than half its length. The posterior spiracular plates (Fig. 104) are partially separated by a dorsoventral median constriction and bear at their margin a pair of dorsal and a pair of short lateral denticles giving the process a somewhat stellate appearance. The palmate hairs are long.

Puparium (Fig. 102).—Length, about 9 mm. Color brownish, rather arched, front end turning downward. The puparium has the same lateral thorns, the same posterior lateral fleshy processes, somewhat shrivelled, and the same posterior respiratory process as the larva. On the upper piece of the operculum or at the posterior border of the inclined anterior region are two yellow pupal respiratory processes, curved backward and outward and beset with small tubercles arranged in double ring-like rows.

Food Habits.—The Illinois specimens bear no food record, but Lundbeck (1916) records this species from the "decaying, humid stub of a beech" and also from the "water in a tree-stub."

Xylota pigra Fabricius

The larval description is that of Johnson (1906); the pupal description and Fig. 98 have been made from two puparia loaned by Dr. C. L. Fluke.

Larva.—Length, 14 mm. The color is dirty yellow or brownish with ten or eleven ill-defined, rugosely wrinkled segments, covered with short hairs, which are somewhat longer on the sides. The first segment is armed on each side with a pair of black thorns, the posterior one curved backward (Fig. 98); the posterior portion bears three pairs of large, hairy

processes, and terminates with a prominent, shiny brown respiratory tube, showing slight annulations on the middle.

Puparium (Fig. 98).—Length, 10-11 mm., width, 4.5 mm., height, 3.5 mm. The color is rich yellowish brown, slightly shining. The body is of the same general shape as that of *X. nemorum,* but arched strongly in the mid-region and sloping more gradually cephalad. The body surface is covered with a fine, rough chaffy pubescence, and the remnants of larval wrinkles remain as short, narrow, transverse folds on the dorsal surface. The segmental spines are three-branched and still quite prominent, especially along the lateral line. The three lateral processes of the posterior segments of the larva are still present and bear numerous long setae.

The lateral thorns are black and, as in other genera, just below the ventral edge of the operculum. The anterior respiratory processes of the larva remain, on the lower edge of the operculum. These are short, yellow-brown cylinders about as long as their diameter and cut off obliquely at the tip. On this oblique elliptical area are nine yellow rays radiating from a central region to the margin; they are illustrated by Greene (1923a). The pupal thoracic horns are bright yellow and located on the upper portion of the operculum. They appear to be indistinguishable from those of *X. fraudulosa* and *X. nemorum.*

The posterior respiratory process is shorter than those of other known species of *Xylota* and bears a marked constriction at the mid-point in its length, beyond which the process is pitted but before which it is smooth and polished. The long plumose hairs on the tip of the process in other species appear to be lacking.

Food Habits.—The puparia from the collection of Dr. C. L. Fluke were obtained from larvae taken under the bark of *Pinus ponderosa* by P. M. Scheffer at Union Flats, Wisconsin. Johnson (1906) gives "beneath the bark of pine logs. It frequented the wet bark near the ground where there was more or less fermentation of the sappy portions of the wood." Greene (1923a) records it as collected under the bark of *Pinus ponderosa* at Larkspur, Colorado.

Xylota bicolor Loew

The following is a brief account taken from the description of the puparium by Greene (1923a).

Puparium.—Length, 12 mm., diameter, 4 mm., cylindrical; dull deep luteous yellow with a brownish tinge, with yellow pubescence. There are two pairs of lateral fleshy processes on the posterior body segments, the cephalic pair smaller.

At the cephalic end and slightly above the lateral edge is a pair of reddish chitinous hooks fused at their base. The larger, or inner, one

curves backward, and the outer one curves out and backward. The larval anterior respiratory processes are yellowish-brown with six finger-like radiating areas on the oblique surface. The pupal respiratory horns are approximately four times as long as wide, reddish-yellow and tuberculated on the distal three-fourths.

Food Habits.—Greene (1923a) records this larva from the frass in a pocket of an old tulip tree, *Liriodendron tulipifera.*

TEMNOSTOMA St. Fargeau and Serville

The larvae of the genus *Temnostoma* are wood-boring syrphids, inhabiting wet, partially decayed logs in moist woodlands. Clean-cut galleries are made with powerful thoracic rakes by means of contractions of the anterior segments. In 1933, Metcalf described in detail the larvae of two species which occurred in a group of more than a hundred in a rotten log in the vicinity of Winnetka, Illinois. However, they are rather rare in this region. Both species in this account are widely distributed in the United States.

The genus can be recognized at a glance by a nearly cylindrical, blunt-ended, elongate body-form and by a delicate, milk-white integument with three dark appendages, two at the anterior extremity and one at the posterior extremity (Fig. 105). The anterior two are the prothoracic rakes, strong, heavily toothed structures, bearing at their base the anterior spiracular plates. The unpaired appendage is the posterior respiratory process. The puparium bears short, perforated thoracic horns in addition to these, as do other saprophytic syrphids, such as *Xylota.*

The following descriptions have been adapted from Metcalf (1933). The figures of the posterior spiracular plates, and of the larva and puparium are drawn from material loaned by Dr. Metcalf.

KEY TO SPECIES OF TEMNOSTOMA

Posterior spiracular plate fused along dorsal fourth, with a prominent, sharp dorsally curved tooth at each lateral margin (Fig. 107); prothoracic rakes heavier with seven or eight teeth in each of the three rows...*bombylans*

Posterior spiracular plate completely but narrowly separated by a shallow groove with numerous transverse folds; eight or more blunt, low teeth distributed around each lateral margin (Fig. 106); prothoracic rakes lighter, with usually five teeth on the inner row, six in the middle row, and seven in the outer row.......................................*balyras*

Temnostoma bombylans Fabricius

Larva (Fig. 105).—Length, 12 mm., width, 3.5 mm., height, 3.5 mm. The larva is milk-white, except for the prothoracic rakes, the adjacent

spiracles, and the posterior respiratory process. There are eight principal body segments, each with several transverse wrinkles and of nearly equal size, besides those of reduced size at the extremities. The head segments are directed ventrad, the inconspicuous mouth parts and rudimentary antennae lying about 1 mm. back on the ventral side. The prothoracic rakes thus lie at the anterior extremity. The rakes measure 0.5 mm. to 1 mm. across and are separated by about twice their width. Each is made up of seven or eight teeth in each of three rows. Segmental spines are present in the usual positions, but are extremely minute. At the middle of the somewhat truncate caudal extremity arises the posterior respiratory process, which is elevated less than half a millimeter; its diameter is about 1 mm.

The drawings of the posterior spiracular plates of both *Temnostoma bombylans* and *Temnostoma balyras* have been accidentally inverted in Metcalf's drawings and the terms used in his descriptions are also inverted. The following description is with corrections of this error. The posterior spiracular plates (Fig. 107) are fused along the dorsal fourth with an overhanging median tooth at the center of the dorsal margin. In addition to this tooth are two others, one prominent, upturned marginal tooth on each lateral margin, dorsal to the second palmate hair. The second palmate hair on each side is much more prominent, erect and stouter than the other three. The numerous slit-like spiracles are longer than those of *T. balyras,* their chitinous expansions averaging seven to each spiracle.

Puparium (Fig. 108).—Length, 10.5 mm., width, 3.5 mm., height, 3.5 mm. The integument becomes parchment-like and yellowish-tan, shrinking somewhat, posteriorly, so that the puparium is of greater diameter at the anterior end. The anterior extremity is an oblique, flat, thickened, blackish plate, nearly circular in outline, which lies flush with the surface of the burrow, forming a little circular plug. On the plate are, dorsally, the two pupal respiratory horns and, at the extreme ventral margin, the two thoracic rakes and the former larval anterior spiracular plates. The pupal respiratory horns are slightly more than half a millimeter long by about one-third millimeter in diameter, polished brown, nearly cylindrical, bluntly rounded at the apex and dotted with minute respiratory apertures. These seem to be very similar in the two species. The posterior end is also thicker and has, for a region around the posterior respiratory process, a hardened, shiny, scaly texture and is deep tan or brown, much darker than the rest of the integument. The posterior respiratory process remains the same as in the larvae, and all of the above characters may be used to separate the puparia of the two species.

Temnostoma balyras (Walker)

Larva (Fig. 106).—In superficial appearance, the larva of *Temnostoma balyras* is similar to that of *Temnostoma bombylans.* The actual differences between the two species are found mainly in the characters of the thoracic rakes, and posterior respiratory process. The differences, pointed out by Metcalf, are as follows: Posterior spiracular plates (Fig. 106) completely but narrowly separated by a shallow groove with numerous transverse folds; no dorsal median tooth. Each plate with eight equivalent, blunt marginal teeth, a pair adjacent to each of the four interspiracular palmate hairs. All the palmate hairs of equal size. The slit-like spiracles shorter than those of *T. bombylans;* the circular plates, smaller. The prothoracic rakes are lighter, the teeth usually being five in the inner row, six in the middle row, and six or seven in the outer row.

Puparium.—The puparium is strongly similar to that of *Temnostoma bombylans* in appearance and dimensions. However, the characters of its posterior respiratory process and thoracic rakes are like those of the larva, and the puparium can be readily distinguished from that of *Temnostoma bombylans.*

Food Habits.—Metcalf (1933) reared both from a moist, decaying, but still firm, hard-maple log. He cites the instances of larvae of this genus being reared from a water-soaked willow log in Pennsylvania and by H. S. Barber from a decaying hickory log near Washington, D. C.

MERODON Meigen

The only representative of this genus in the United States is *Merodon equestris* Fabr., the large narcissus fly or the daffodil fly. Like its companions in habit, *Eumerus* spp., it is an introduction within the last twenty years from Europe. It is now established in the bulb-growing regions of the United States. Only one specimen, a larva collected by Dr. T. H. Frison at Canton in 1925 and now in the collection of the Illinois State Natural History Survey collection, has been recorded from Illinois. Though the preferred host plant of the larvae is narcissus, they have been recorded from many genera of the lily family. Unlike *Eumerus,* there is only one generation a year. The winter is passed in the bulbs as full-grown larvae. In March and April, the larvae leave the bulbs, usually through the neck, and pupariate in the soil about half an inch below the surface. The pupal period is unusually long for a syrphid, 35 to 40 days. The flies emerge in April and May and lay their eggs in the soil around the base of the bulbs. The newly hatched larvae usually burrow through the basal plate of the bulbs. The center of the bulb is hollowed out; the

cavity soon becomes largely filled with decaying matter and excrement of the consistency and color of peanut butter. Bulbs are usually so far consumed that they will not grow, and when they do grow they produce only weak yellowed leaf growth, but no bloom. The larvae sometimes migrate from one bulb to another, if the food is exhausted in the first. Hodson (1932b) says that the larvae pass through four instars. They are full grown by fall.

Merodon equestris Fabricius

Since *Merodon equestris* has become a major pest to the bulb-growing industry it has been described frequently in the literature, but since its habits and large size make it easy to recognize it is usually described only with the barest brevity. Childs (1914) gives three very brief descriptions and photographs *in situ* of the larva and adult; Essig (1926) gives another brief description of larva and puparium and also illustrates with photographs. Wilcox and Mote (1927) give a brief description and illustrate with photographs of egg, larva, puparium, and injury. Wilcox (1927) gives a very similar account with a figure of an adult. The best account is by Hodson (1932b) in connection with a bionomic study, but much is omitted from his descriptions. He figures first instar and fourth instar larvae and gives photographs of egg, puparium, and adults.

The descriptions given below and the drawings have been made from material from Sumner, Washington, given to the writer by Mr. Randall Latta.

Larva (Fig. 109).—Mature larva, 15-19 mm. long, 4-6 mm. wide, 4-5.5 mm. high. The larva is bent into a strong curve, the body very roundly arched on the dorsum and slightly flattened on the ventral side, but not conspicuously broader than high. The color is dirty yellowish or light yellowish-brown.

The sausage-like body is plainly divided into segments and tapers little before the rounded ends. On the posterior segment is a pair of minute fleshy papillae, lateral and ventral to the posterior respiratory process. Each bears a simple long segmental spine and a tuft of body spinules. The entire surface of the integument is covered with an even pile of minute spinules. The segmental spines are long and conspicuous and consist of a tapering needle-like terminal segment, eight times as long as it is wide at the base, on a wide thick basal segment about four times as wide as the terminal segment.

The anterior segments are corrugated with conspicuous folds forming a false head. The mouth hooks and antennae are large and conspicuous. The anterior spiracles are short, brown, cylindrical projections on the dorsal side of the false head. On the dorsum of the second segment

behind the anterior spiracular processes are two swollen oval areas, the sites of the future pupal respiratory horns. There are no conspicuous ventral prolegs, and ventral tufts of setae are lacking.

The posterior respiratory process is a shining, coal-black, short, truncated, oval tube about as long as it is wide. Completely around its base runs a constriction, cutting off a basal rim; from here the completely fused tube tapers with a series of parallel rugose folds to the smooth rim of the spiracular plate (Fig. 109). The spiracular plate (Fig. 112) is a smooth plane with two sunken broadly reniform depressions in the center; these are the circular plates. The spiracles are three pairs of elaborately looped slits without denticles, flat with the surface. On the edges of the plate are four pairs of minute groups of branched hairs. The ventral side of the respiratory process bears a groove of varying depth.

Rectal gills were not found in this species.

Puparium (Fig. 111).—Length, 13 mm., width, 5.5 mm., height, 5.5 mm. Tough and leathery, dark brown to black in color, but may be reddish. The puparium is not curved as in the larva, but is nearly straight on the ventral side, higher on the anterior end, and sloping evenly to the rounded posterior end. It is circular in cross section at any point. The lateral papillae of the larva persist in much the same size as before but the spines are reduced. The integumental spinules form a rough, felted surface, much wrinkled toward the posterior end. In the middle of the upper half of the operculum on each side are the curved, horn-like pupal respiratory processes, which, according to Hodson, are not extruded until the eighth to tenth day after pupariation. Its surface is perforated with minute circular apertures. The small larval anterior spiracular processes still persist on the lower half of the operculum. The black, glossy posterior spiracular process is similar to that of the larva.

Food Habits.—The preferred host is narcissus. In addition Hodson (1932b) lists hyacinth and tulip rarely, *Amaryllis, Habranthus, Vellota, Eurycles, Galtonia, Leucojum, Galanthus,* the wild snowdrop of England, and *Scilla nutans,* the wild hyacinth, all members of Liliaceae. Essig (1926) lists in addition *Hippeastrum.*

Eumerus Meigen

The flies of the genus *Eumerus* are known as the lesser bulb flies or lunate onion flies. Three species occur in the United States, all of which have been introduced with importations of bulbs from Europe. From the first introduction of this genus into the United States, which appears to have been in 1904, when a single specimen was collected by a Dr. Fletcher at Ottawa, Canada, it has spread rapidly in the East and on the Pacific coast. It has probably been repeatedly introduced in shipments of bulbs from Holland, France, and England. The lesser bulb fly was always

assumed to be *Eumerus strigatus* Fallén. But in 1920, J. E. Collin called attention to the fact that another very similar species, *tuberculatus* Rondani, was far more numerous in England than *strigatus*. C. H. Curran found, when he examined the specimens in the Canadian National Museum, that all previous reports of *strigatus* were actually *tuberculatus*. There has been much confusion in the records in the United States as well, since for many years the damage caused by the lesser bulb fly was always attributed to *strigatus*. In 1927 another species, *narcissi*, was distinguished by Leslie M. Smith in California from narcissus bulbs imported from France. Latta and Cole (1933) describe the adults of these three species and give tables of characters distinguishing between them.

Larvae of *Eumerus strigatus* from Centralia, Illinois, are in the University of Illinois collection. *Eumerus tuberculatus* is rare in Illinois, but there are thirteen adults from two localities in the state in the State Natural History Survey collection. *E. narcissi* is found in France and, in America, only in California. The larvae of *Eumerus* have been recorded, in addition to many kinds of bulbs, from manure (Hodson, 1931), but in this, they do not reach complete development. In Java, the larva of *Eumerus parallelus* has been found in the liquid of the leaf axils of *Colocasia indica*. The larva is figured by Sack (1931); it differs markedly from the bulb-feeding species of *Eumerus*. Although the adults of the bulb-feeding species show a marked preference for diseased or injured bulbs in egg-laying, there is no doubt that the larvae are truly phytophagous. The eggs are laid on the soil near a bulb or on the dried foliage. According to Wilcox (1926) the newly hatched larvae enter the bulb at the base or neck, but Hodson (1927) states that the young larvae crawl down into the bulb neck, where there is a small amount of damp and rotting tissue meeting the living neck. They begin feeding here and so enlarge the rotted area, gradually working down into the heart of the bulb, which becomes slimy and decayed. From then on, fresh living tissues are torn down and reduced, partly by the salivary juices, to a state of liquifaction so that the interior of the bulb soon becomes a slimy, excrementitious mass. Puparium occurs in a dry place, either on the shrivelled foliage or in the adjacent soil. The lesser bulb fly usually has two generations a year.

The larvae are all small to medium-sized (7-12 mm.), dirty white or brownish, subcylindrical maggots with a prominent brick-red posterior respiratory tube. A characteristic group of four fleshy processes is found on each side of the posterior segment; a large dorsal papilla, two small twin papillae in the middle position and a still larger ventral papilla, which extends out on each side of the respiratory process. The segmental spines are double and the whole integument covered with short spines. The larvae of *Eumerus* are most likely to be confused with the larvae of *Syritta pipiens*.

KEY TO SPECIES OF EUMERUS

Mandibular sclerites larger, with usually seven prominent teeth, rarely less than six (Fig. 114); groove between antennal tubercles is shallow or absent (Fig. 116)..*strigatus*

Mandibular sclerites smaller, with less numerous teeth, usually five prominent pairs, occasionally six (Fig. 110); groove between antennae pronounced (Fig. 115)..*tuberculatus*

(For other characters see comparison under *tuberculatus*)

Eumerus strigatus Fallén

The egg, larva, puparium, and injury were described by Wilcox (1926) and illustrated by photographs, and by a figure of the puparium. Essig (1926) describes the stages of this fly very briefly and gives other photographs of the larvae, puparium, and injury. Another account of the life history of *Eumerus strigatus* is given in 1927 by Wilcox illustrated with new photographs. Keifer (1930) gives a brief description of the larva but no figures. Hodson (1931) made a detailed study of *Eumerus strigatus* and *tuberculatus* and compared them, but this author, like all the previous authors, neither studied nor figured the segmental spines or posterior respiratory process.

The descriptions given below, and the figures, have been made from specimens kindly sent by Mr. Randall Latta of Sumner, Washington, and from others collected at Centralia, Illinois.

Larva (Fig. 113).—Mature larvae are from 8-10 mm. long, 2.5 mm. wide, and 1.8 mm. high. The living larvae, according to Wilcox (1927), are usually a dirty greenish-grey but may vary from white to reddish. The wrinkled body is compactly rounded and somewhat flattened ventrally with three short papillae and one rather long papilla on each side of the last segment. The characteristic arrangement is a large, short, dorsal papilla, a twin tubercle in a median position of two very small, short papillae, and a longer ventral projection that extends outward from the posterior angle of the last segment, almost or as long as the respiratory tube. The papillae terminate in a cluster of three or four curved spines.

The integument is covered with rows of little tubercles, which are the basal papillae of the segmental spines. The segmental spines (Fig. 119) are remarkable in that they consist of a pair of curved terminal spines on a single broad basal piece. On the fleshy papillae the spines are three or four to a basal piece. The entire dorsum is covered with closely set but unevenly distributed spinules. They are longest and most dense on the ridges and little tubercles of each body segment.

On the anterior end protrude the prominent antennae, two pale, rounded, fleshy tubercles, each surmounted by two small papillae (Fig. 116). In this species the groove between the tubercles is shallow, or

absent. The mouth hooks are broad, heavy toothed structures with a variable number of denticles, but according to Hodson (1932) always with more than six and usually seven large denticles on each mandibular sclerite (Fig. 114). The anterior spiracular processes are inconspicuous light brown projections.

The posterior respiratory process (Fig. 127) is a single, smooth, straight, polished tube, tapering slightly to the evenly rounded ends with the two component tubes completely united into one. It is only about twice as long as its width at the tip. The spiracular plates bear, in a central depression, two circular plates and on a flat, crescentic ridge are borne three roughly cogwheel-like spiracles. At the margin of each plate are four tufts of branched, fringing hairs (Fig. 122).

The rectal gills consist of a pair of three-fingered structures, the mesal finger shorter than the outer two (Fig. 125).

Puparium (Fig. 123).—Length, 6-8 mm., 3 mm. wide, 2.8 mm. high. The color according to Wilcox (1927) is light, dirty grey, but may be brown to red. The surface is rough, due to the presence of numerous minute spinules and retains the fleshy papillae of the larva in somewhat shrunken condition. The front of the puparium is evenly rounded but somewhat narrowed, and the posterior end tapers into the prominent smooth tube of the posterior process. The ventral outline is almost perfectly straight. On the anterior end, faint whitish lines indicate the future operculum and its central line of cleavage. On the upper section of the operculum are found the prominent pupal respiratory horns which are not visible in the freshly formed puparia, but are extruded later. They are slightly curved, brown, tapering structures with minute circular apertures on small nodules (Fig. 120). On the lower section of the operculum, the larval anterior spiracles are still visible. The posterior respiratory plates are the same as in the larva (Fig. 122).

Food Habits.—With the possibility of some confusion with *tuberculatus* the larva has been recorded attacking narcissus, hyacinth, tulip, amaryllis, iris, shallots, onion, parsnip, potato, carrots, and rotting grapefruit (Keifer, 1930).

Eumerus tuberculatus Rondani

In 1920, Collin pointed out that in England lesser bulb flies believed to be *E. strigatus* were in reality *tuberculatus,* which was much more abundant there. This indicates how similar the two species are and in what probable confusion many of the American records and descriptions may be. Collin gives in this paper a description of the larvae of *tuberculatus* and *strigatus,* but they are not differentiated. Hodson (1927), in a

bionomic paper, gives brief descriptions and photographs of the egg, larva, and puparium of *tuberculatus*. In 1931, Hodson again gives a description of *tuberculatus* comparing it with *Syritta pipiens* and figures for each the larva, larval mouth hooks, and puparium. In 1932a, the same author published a comparison of the larvae of *E. strigatus* and *E. tuberculatus* in an attempt to find key characters, but even with this study it is not always possible to determine a single specimen with certainty. Hodson's key is quoted below.

Larva.—The larva of *E. strigatus* is so similar to that of *E. tuberculatus*, that the description need not be repeated. According to Hodson the chief differences between the two species are as follows, the most important being the first two:

	E. strigatus	*E. tuberculatus*
Mandibular sclerites	Larger, teeth more numerous, usually 7 prominent pairs, rarely less than 6 (Fig. 114).	Smaller, teeth less numerous, usually 5 prominent pairs, very occasionally 6 (Fig. 110).
Antennae	Groove between tubercles bearing antennae shallow or absent (Fig. 116).	Groove pronounced (Fig. 115).
Anterior spiracles	Color darker.	Color lighter.
Posterior spiracular process	Shorter, wider, color darker.	Longer, narrower, color lighter.
Minute scattered spines	Darker, less abundant.	Lighter, more abundant.
Larger (segmental) spines	Darker, shorter.	Lighter, longer.
Anal processes	Appreciably darker than remainder of integument.	Unicolorous with or only slightly darker than remainder of integument.

Puparium.—The puparium cannot be differentiated from that of *E. strigatus* unless dissected for the mandibular sclerites.

Food Habits.—The food habits are the same as for *strigatus*.

Syritta St. Fargeau and Serville

The only species of this genus in North America is the common and cosmopolitan *Syritta pipiens*, which occurs throughout the world according to Sack (1931). The larva is a short-tailed slime dweller, breeding usually in the manure of animals. A species in Sumatra, *Syritta capitata*, lives in the fluid of a pitcher plant, *Nepenthe tobaica* (Sack, 1931).

Syritta pipiens Linneaus

The immature stages of *Syritta pipiens* have been described in detail and figured by Metcalf (1916). The rectal gills, posterior spiracles, and cross section of the pharynx are figured by Krüger (1926) who gives an exhaustive morphological account of the larva. Hodson (1931) describes the larva and puparium of *Syritta pipiens* in comparison with those of *Eumerus tuberculatus* and figures the cephalopharyngeal skeleton, larva, and puparium of both. Johannsen (1935) describes again the larva and puparium of *Syritta pipiens,* using the descriptions of Metcalf and the figures of Metcalf and Krüger.

In the description that follows, the account has been taken from those of Metcalf and Hodson. The larva has been redrawn from Hodson, the pupal respiratory horn, the posterior fleshy processes, and posterior spiracular plates from Metcalf, and the rectal gills from Krüger. The puparium was drawn from a specimen loaned by Dr. C. L. Fluke.

Larva (Fig. 117).—Length, 10 mm., width, 2.75 mm., height, 2 mm. The larva is broadly fusiform, tapering moderately toward the false head and more narrowly at the posterior end, and broadest from segments five to nine. The color is dirty yellowish and the entire body is covered with pale and delicate, close-set microscopic hairs, which are longer on the more exposed portions. The body bears, just anterior to the posterior respiratory process, three pairs of pointed fleshy projections (Fig. 128).

The anterior segments are differentiated into a false head with about a dozen longitudinal furrows. The anterior spiracles are very dorsal in position, located between the first and second furrow from the midline and are sessile, each with apparently three rounded nodules on its summit. The head has a transverse band of microscopic hooklets above the mouth. There are seven pairs of prolegs; each proleg has about two dozen hooklets of varying sizes. On segments eleven and twelve are the conspicuous lateral processes, the anterior, shortest one on the eleventh, the middle and posterior ones, which are progressively longer, on the twelfth. They are covered with spinelets, which are longer toward the tip.

The posterior respiratory process is a brown, chitinized polished tube, about 0.75 mm. long (Fig. 128). It is straight, tapering, and very slender, about five times as long as its width at the tip. The tubes are semitransparent, permitting the large tracheal trunks to be seen throughout its length. The posterior spiracular plates (Fig. 118) have centrally located circular plates and three pairs of contorted spiracles which are ornamented around the edge with from nine to fourteen lateral projections or denticles which are irregular in size and irregularly shaped. The plates are each surrounded by four tufts of feathered hairs.

According to Krüger (1926) the rectal gills are twelve-branched (Fig. 124).

Recognition Characters.—1. Yellowish larvae about 10 mm. long with three pairs of posterior fleshy processes, the first shortest and the last longest (Fig. 128). 2. Seven pairs of prolegs each with two dozen hooklets of varying sizes (Fig. 117). 3. Shape of the aperture of the spiracles contorted and irregularly toothed with nine to fourteen denticles (Fig. 118). 4. Slender, straight posterior process, tapering toward the tip and five times as long as wide at the top (Fig. 128).

Puparium (Fig. 126).—Length, 6.8 mm., width, 2.95 mm., height, 2.68 mm. Elongate-ovate in outline, a little more attenuated posteriorly, nearly circular as seen from the front, a little flattened on the venter. Color yellowish white, darkening to dull muddy brown. The remnants of the three pairs of projections are still readily visible on the anal segments but the prolegs have disappeared and even the hooklets are difficult to find on the general roughened and soiled integument.

The pupal respiratory processes (Fig. 121) protrude from the upper half of the operculum as blunt, club-shaped projections. The enlarged distal half is studded with about 75 minute nodules in which are found the spiracular apertures. The posterior spiracular process is like that of the larva.

Food Habits.—The stages of *Syritta pipiens* have been reported from cow and horse manure, from guinea pig manure and from human excrement. It has also been found in decayed and rotting tulip bulbs and in heaps of vegetable refuse (Hodson, 1931).

BRACHYPALPUS Macquart

The larvae of this genus are short-tailed saprophytes dwelling, usually, in rotting wood. They are characterized by a carrot-shaped body, slightly flattened dorso-ventrally, and the typical features of saprophytic larvae, a false head, hooked prolegs, and posterior spiracular plates bearing palmate hairs and convoluted spiracles.

KEY TO SPECIES OF BRACHYPALPUS

Length of posterior respiratory process about three times as long as broad; a single heavy lateral hook on each side of false head; campaniform pupal respiratory horns covered with numerous small cones on each of which is a stellate spiracle (Figs. 130, 132, 134) .... *frontosus*

Length of posterior respiratory process one and a half times as long as broad; two, closely adjacent lateral hooks on each side of false head; conical pupal respiratory horns with numerous, but fewer, low ring-like tubercles with a depression in the center (Figs. 131, 133) .... *rileyi*

Brachypalpus frontosus Loew

The larva and puparium of this species have been described by Malloch (1915) who figured the larva, puparium, front view of head, and the pupal prothoracic thorns. The puparium was described previously by Parker (1915) very briefly; he failed to observe the lateral thorns at all.

The larva and puparium are described from specimens in the Illinois Natural History Survey collection.

Larva (Figs. 129, 134).—Length, 19 mm., width, 4 mm., height, 3.5 mm. The body color is creamy white but the posterior respiratory process is light brown deepening to reddish brown at the tip. The body is carrot-shaped, slightly flattened dorso-ventrally and deeply and regularly wrinkled. On the ventral surface the papillae of the ventro-lateral segmental bristles form a pair of prominent longitudinal, scalloped carinae. Surrounded by these are six pairs of prominent prolegs each armed with three rows of brown recurved teeth. A seventh pair, similarly armed, is located on the false head on a level with the lateral hooks.

On the anterior margin of the false head are three and a partial fourth row of small, dorsally-curved, dark brown hooks of three sizes, the largest in the most posterior row. Well posteriad of these and just laterad of the short peg-like anterior respiratory processes is a single pair of heavy, black hooks curving back and outward.

The entire integument is beset with a soft, white pile of minute but stout hairs. The segmental spines, all raised on prominent papillae are either four- or five-branched. There are three pairs of lateral processes posteriorly. The most anterior pair are mere papillae and dorsal in position. The second pair are lateral in position and about twice as long as the first, and the last pair are lateral, four times as long as the first and curved back around the last segment.

The posterior spiracular plates (Fig. 129) are typical for a saprophytic species and are at the apex of a fused respiratory process about 2 mm. in length.

Puparium (Figs. 132, 137).—Length, 14 mm., width, 4.5 mm., height, 4 mm. The color is medium burnished brown. The puparium is moderately inflated; the wrinkles and carinae of the larva, much reduced. The segmental spines and posterior processes are much shrivelled but retain the characters of those of the larvae. The six posterior prolegs remain visible as groups of strong hooklets but are hardly raised from the surface. The anterior pair are almost invisible in the great contraction of the anterior segments. The prominent pair of single lateral hooks are now at the ventral cephalic edge of the puparium, outside of the operculum and may be found even if the operculum has been lost. The pupal respiratory horns (Fig. 132) are short blunt domes, covered with

tubercles, each of which bears a stellate aperture or group of apertures at the tip. Malloch (1915) describes the pupal respiratory processes of this species as being represented only by slight callosities. The writer believes that in his specimens they had not yet been extruded. The posterior respiratory process is similar to that of the larva.

Food Habits.—The specimens described by the writer were not accompanied by collection data. Malloch (1915) records this species from under bark on a rotten tree trunk near Urbana, Illinois, and Parker (1915) recorded it from under moss on the top of a mountain range south of Hagerstown, Maryland.

Brachypalpus rileyi Williston

The only account of this species is that given by Greene (1923a) in which he describes the larva from two larvae taken at Glen Echo, Maryland, and the puparium from two puparia collected at Dead Run, Virginia. Adults of this species have been collected in Illinois. The descriptions which follow are adapted from Greene.

Larva.—Length, 9 mm., diameter, 3.5 mm., length of posterior respiratory process, 1 mm. Nearly cylindrical, with the sides about parallel, dull, light brownish-yellow. The body is transversely wrinkled and the entire surface closely set with short, fine pubescence; there are numerous small tufts of setae arranged in longitudinal rows on the dorsum. The last three segments terminate laterally in a long conical projection, each with numerous dark brown spines. These projections increase in size toward the caudal end.

At the anterior end, on each lateral edge is a small, nearly circular, reddish chitinous plate, each bearing two prongs (Fig. 131); the inner one points up and back toward the dorsum, the other points out and backward. Just above these are the elliptical, deep reddish anterior spiracles. They are about as long as their greatest diameter and are cut obliquely toward the outside; this surface is smooth with seven finger-like light areas radiating toward the inner edge.

The posterior respiratory process is 1 mm. long, heavily chitinized, deep reddish-yellow. Along the center is a vertical groove reaching to the brownish-black apex. The tip, in outline is crudely shaped like a figure 8. The circular plates are circular and near the center. There are four sinuous slits in each half and Greene's illustration shows no sign of minute chitinous denticles along the slits as in *frontosus*. It shows no palmate hairs as in *frontosus* but at the outer margin of each spiracular plate are two lateral denticles.

Puparium.—Length, 9 mm., diameter, 4.25 mm. Not so rugose as the larva; dull, dark reddish-brown with entire surface covered with a short

microscopic pubescence. At the apex are the double hooks of the larva. The pupal spiracles are reddish-black, cone-shaped, leaning slightly outward and backward. Their height is only slightly more than the diameter at the base. There are numerous tubercles on the surface; each tubercle is nearly round with a faint depression in the center. The posterior respiratory process is similar to that of the larva.

Food Habits.—The larvae were found under the bark of hickory and the puparia in a cedar stump.

Tropidia Meigen

The single known larva of this genus, *Tropidia quadrata* Say, possesses, on each side of the false head two heavy lateral hooks, their bases separated by a little more than their length. This seems to be the most distinctive feature of the species.

Tropidia quadrata Say

The puparium was described and figured by Malloch (1915) from specimens found floating in water near Havana, Illinois. Metcalf later (1916) described all the stages in detail and illustrated them with numerous drawings. The following descriptions and the figures have been taken from the latter author.

Larva (Fig. 138).—Length, 16 mm., width, 3.5 mm., height, 3.5 mm. The larva is dirty white or clay yellow, nearly cylindrical, the anterior segments forming a globose false head and the posterior segments tapering rapidly before the posterior respiratory process. On each side of the posterior segment are three conical fleshy protuberances.

The body surface is closely set with microscopic, pale brown, short, soft hairs. The segmental spines are three-branched. There are seven pairs of fleshy prolegs on the ventral surface, each bearing a crown of recurved hooks, the anterior ones largest.

The dorsal part of the bulbous false head bears two large lateral thorns on each side, their bases about 0.35 mm. apart. Between the thorns of each side and dorsad of them are three irregular transverse rows of smaller and various-sized thorns. Near each side and among these hooks is the sessile anterior larval spiracle bearing four rounded nodules.

The posterior respiratory process (Fig. 139) is about 0.75 mm. long and is grooved along the mid-dorsal and mid-ventral lines and truncated at the tip. The spiracles are roughly S-shaped and each ornamented with about twenty short, rounded, lateral denticles irregular in size and irregularly distributed. The palmate hairs are quite short and some are further subdivided.

Puparium (Fig. 141).—Length, 8-9 mm., width, 3.5 mm., height, 3mm. The puparium is pale brown and broadest a little in front of the middle where it is nearly circular in cross section. It is only a little narrowed and globose in front, but evenly tapered caudad to about one-third the width just in front of the posterior respiratory process.

On the dorsal transverse piece of the operculum is borne a morel-like pupal respiratory horn which bears on its distal surface a hundred or more minute papillae. The large lateral hooks are drawn forward to lie at the anterior extremity of the ventral line, outside of the operculum. The larval anterior respiratory processes are included on the operculum.

The three pairs of lateral fleshy processes, somewhat shrunken and indurated, are visible posteriorly, and the larger hooklets of the prolegs can be distinguished. The posterior respiratory process is the same as for the larva.

Food Habits.—The larva was found by Metcalf (1916) in moist, but not watery masses of human excrement and well-decayed potatoes.

BRACHYOPA Meigen

The single known larva and puparium of this genus is that of *Brachyopa vacua* O. S. which was described by Greene (1917). The larva and puparium are so similar that only the puparium was figured by him. The following brief account is taken from Greene's description.

Brachyopa vacua Osten Sacken

Larva.—Length, 8 mm., width, 3mm., nearly cylindrical. The color is dull, opaque yellow-ochre, brown, or black. The first segment is pointed; the greatest width is at the fourth segment, and it gradually decreases toward the caudal end.

The entire body is finely rugose; the dorsum very rugose transversely; in the middle of each segment is a transverse depression or groove. On the base of the first, pointed segment is a transverse row of six fleshy tubercles and on all succeeding segments, eight or ten fleshy tubercles just above the center. These bear the three- to four-branched segmental spines. In addition to the prominent tufts of segmental spines there are, at the base of the first segment, a row of small, fleshy, bristle-like projections; all other segments have three rows each of similar projections. The entire ventral surface of the larva is covered with minute, brownish-black spines.

The anterior respiratory processes are a pair of conical dark reddish-brown projections on the lateral margins of the first segment. The posterior respiratory process is nearly cylindrical, 1 mm. long, mostly dull black but shiny at the apex.

Puparium (Fig. 140).—Length, 7 mm., width, 4.75 mm., nearly cylindrical. The color is not given. The puparium is very similar to the larva except for the characters noted. In profile, the puparium slopes from about the middle of the second segment anteriorly, having a wedge-shaped appearance. The integument is much smoother than that of the larva; all the fleshy, bristle-like projections are much compressed and shrivelled.

The pupal spiracles are reddish-brown, conical, and curved outward. They bear numerous small tubercles around the sides with one at the apex.

Food Habits.—Greene (1917) records the larvae from the juice of decaying fungi under dead bark (*Liriodendron*) at Falls Church, Virginia.

Volucella Geoffroy

The larvae of *Volucella* are large, elongate, nearly bare maggots with a short, stump-like posterior respiratory process and with six, more or less elongate, fleshy tentacle-like processes of the posterior segment arranged in a semi-circle around the posterior respiratory process. In one European species, *V. inanus*, and in the North American species, *V. nigra* Greene (1923c), the fleshy processes are very short and have become mere papillae, but they are arranged in the same transverse curved row as the longer processes of other species.

The writer has no determined material of the immature stages of this genus; the drawings (Figs. 142, 145) were made from a larva collected by Dr. T. H. Frison in the nest of *Bombus fervidus* Fabr. at Baraboo, Wisconsin. There are few American species of which the immature stages have been described, but a very exhaustive account of the immature stages of several European species is given by Jules Künkel d'Herculais (1875).

The food habits of *Volucella* are of two distinct kinds. As far as known all the species in this region are scavengers in the nests of bumble bees, consuming the wastes of the nest and the dead larvae and pupae of the bees. In the Southwest the larvae of *Volucella* approach in habits the bulb flies, living in decaying cavities of cacti which are constantly enlarged by the insects. A review of the literature on food habits is given by Metcalf (1913b).

Microdon Meigen

The remarkable sub-hemispherical larvae of *Microdon* (Fig. 143) are comparatively rare; the immature stages of only a few species have been described by entomologists. Wheeler (1910) states that these larvae have been repeatedly described as molluscs under the generic names of *Scutelligera, Parmula,* and *Ceratoconcha* and as Coccidae.

Although in most species there is no trace of segmentation and the segmental bristles appear to be missing, these unusual larvae do show at least one characteristic feature of Syrphidae in the presence of a fused posterior respiratory process. The details of the larva have been discussed on page 14. On pupariation, the creeping sole becomes attached to the walls of the ant galleries and the integument becomes hard, dark, and brittle, but there is little change in shape. These puparia extrude, as all the saprophytic Syrphidae, a pair of pupal respiratory horns from the upper portion of the operculum.

The writer has not had access to many specimens, and these have been of doubtful determination. The figures given (Figs. 143, 144) were drawn from a larva in the Illinois State Natural History Survey collection determined by J. R. Malloch as *Microdon globosus* Fabr., a species which, according to Wheeler, is synonymous with *M. tristis* Loew. Its appearance does not agree particularly well with Wheeler's figure of the larvae of *M. tristis* but it may be that species.

The immature stages of the following species have been described. *Microdon tristis* Loew, a reddish-brown reticulated form from the nests of *Formica schauffussi*, was described and figured by Wheeler (1908), and the puparium and posterior spiracles of the same species have been figured by Metcalf (1913b). Greene (1923a) described and figured *Microdon coarctatus* Loew, a milky-white larva covered with cone-like projections, from the nest of a small black ant, *Monomorium minutum* Buckley at Difficult Run, Virginia, and (1923b) *Microdon megalogaster* Snow, a dull brownish-red, faintly reticulated larva from the nest of *Formica fusca subsericea* Say at Falls Church, Virginia. Cole (1923) described the stages and gave a figure of the puparium of *Microdon piperi* Knab, a western species which ranges north along the Pacific Coast. The larva is bluish green with the median ridge and margins of the body brown. It inhabits the nest of *Camponotus maculatus vicinus* Mayr. In addition to these known species, the larvae of at least two other unknown American species of *Microdon* have been described by Wheeler (1901) and by Brues (1903).

The food habits of the larvae were for a long time problematical, although it was known that the larvae die when removed from association with their host ants. In 1911, however, Donisthorpe in England succeeded in showing that the larvae feed on the ejected material from the infrabuccal pockets of the ants. The fact that they are scavengers is interesting in view of the fact that, though highly modified they have retained two very typical characteristics of the saprophytic division of the syrphid larvae, the pupal respiratory horns and the elaborate posterior spiracles.

Cerioides Rondani

Cerioides signifera (Loew)
(= *Ceria willistoni* Kahl, *Ceria signifera* Loew)

The puparium of *Cerioides signifera* (Loew) was briefly described by Banks (1903), and a puparium of *C. signifera,* which is considered by Metcalf and Curran to be a synonym of *willistoni,* was described briefly by Johnson (1893). Both descriptions are rather general. The puparium was again described by Malloch (1915) in much greater detail, and from this description the following has been taken. The figure, however, was drawn from a specimen in the Illinois Natural History Survey collection.

Puparium (Fig. 146).—Length, 14 mm., posterior respiratory process, 4 mm. Yellowish white, mottled with brown or blackish, opaque. The operculum was missing.

The dorsum is ornamented with a median longitudinal series of paired, wart-like tubercles, six pairs in all, the dorso-lateral margins each with six wart-like tubercles in a longitudinal row and slightly caudad of the corresponding sub-median one; between the sub-median and dorso-lateral warts is a longitudinal series of much smaller warts. There are four other such longitudinal rows of much smaller warts on the lateral surfaces, the medio-lateral line with a pair of small warts, the anterior of each pair white, with a small brown spot ventrad of it. The larger tubercles are armed with setulose hairs at the apices and the general body surface is covered with microscopic pale hairs.

On ventral surface of segments 1 to 4 are pairs of slightly raised circular areas crowned with dark setulose hairs; on the remaining segments are discernible circular areas but no setulose hairs. On each of the posterior two segments is a transverse series of four thorn-like processes.

The posterior respiratory process is shining brown, completely fused, transversely oval in cross section, and seven times as long as thick.

Food Habits.—The puparium was recorded from upon oak bark at Falls Church, Virginia, by Banks (1903) and from an oak leaf near Bala, Pennsylvania, by Johnson (1893). Banks states that the larva of *Cerioides* is supposed to feed in the flowing sap of trees. The known habits of the Indian species described by Bhatia (1931) bear out this statement.

APPENDIX

List of Known Parasites

The parasites listed for each species are those reared by the writer unless followed by a reference to another author. The letters I, C, and F following the name of the parasite refer to Ichneumonidae, Chalcidae, and the subfamily Figitinae of the Cynipidae respectively.

Syrphid	Parasites
Allograpta obliqua	*Diplazon laetatorius* (Fabr.) (I)
	Diplazon scutellaris (Cress.) (I)
	Syrphoctonus agilis (Cress.) (I)
	Syrphoctonus pacificus (Cress.) (I) (Cole, 1933)
	Homotropus humoralis (Prov.) (I) (Cole, 1933)
	Pachyneuron allograptae Ash. (C) (Cole, 1933)
	Conostigmus sp. (C) (Cole, 1933)
	Bothriothorax sp. (C) (Malloch, 1915)
Sphaerophoria cylindrica	*Diplazon laetatorius* (I)
	Diplazon scutellaris (I)
	Syrphoctonus agilis (I)
	Syrphoctonus pacificus (I) (Cole, 1933)
	Homotropus humoralis (I) (Cole, 1933)
	Pachyneuron allograptae (C) (Cole, 1933)
	Conostigmus sp. (C) (Cole, 1933)
Mesogramma polita	*Zamicrotoridea syrphicola* Ash. (I)
	Eupteromalus dubius (Ash.) (C)
	Syrphophagus flavipes Ash. (C) (Sanderson, 1900)
	Pachyneuron mesograptae Ash. (C) Sanderson, 1900)
Eupeodes volucris	*Diplazon laetatorius* (I) (Campbell and Davidson, 1924)
	Syrphoctonus maculifrons Cress. (I) (Campbell and Davidson, 1924)
Lasiophthicus pyrastri	*Syrphoctonus maculifrons* (I) (Kamal, 1926)
	Syrphoctonus pacificus (I) (Kamal, 1926)
	Homotropus humoralis (I) (Kamal, 1926)
	Pachyneuron allograptae (C) (Kamal, 1926)
	Bothriothorax californicus How. (C) (Kamal, 1926)
	Conostigmus sp. (C) (Kamal, 1926)
Syrphus rectus	*Diplazon laetatorius* (I)
	Zamicrotoridea syrphicola (I)
	Bothriothorax peculiaris How. (C)
	Pachyneuron allograptae (C)
Syrphus ribesii-vittafrons	*Diplazon laetatorius* (I)
	Bothriothorax peculiaris (C)
Syrphus torvus	*Diplazon laetatorius* (I)
	Syrphoctonus pleuralis (I)
	Callaspidia provancheri Ash. (F)

Syrphid	Parasites
Metasyrphus wiedemanni	*Diplazon laetatorius* (I)
	Syrphoctonus agilis (I)
	Bothriothorax peculiaris (C)
	Aspicera sp. (F)
Metasyrphus vinelandi	*Diplazon laetatorius* (I)
	Diplazon scutellaris (I)
	Syrphoctonus agilis (I)
	Aspicera sp. (F)
Metasyrphus perplexus	*Diplazon laetatorius* (I)
Metasyrphus meadii	*Diplazon laetatorius* (I) (Kamal, 1926)
	Syrphoctonus maculifrons (I) (Kamal, 1926)
	Syrphoctonus pacificus (I) (Kamal, 1926)
	Homotropus decoratus (Cress.) (I) (Kamal, 1926)
	Bothriothorax peculiaris (C) (Kamal, 1926)
	Pachyneuron allograptae (C) (Kamal, 1926)
	Syrphophagus sp. (C) (Kamal, 1926)
"Metasyrphus" emarginatus	*Syrphophagus smithi* Kamal (C)
	Homotropus bicapilleris var. *albopictus* Davis (I) (Fluke, 1931)
Paragus bicolor	*Diplazon laetatorius* (I)
Paragus tibialis	*Diplazon laetatorius* (I)
	Pachyneuron allograptae (C)
	Pachyneuron sp. (C) (Campbell and Davidson, 1924)
	Aspicera sp. (F)
Baccha clavata	*Diplazon laetatorius* (I)
	Diplazon scutellaris (I)
	Pachyneuron californicum (C) (Campbell and Davidson, 1924)
Eumerus strigatus	*Rhembobius abdominalis* (Prov.) (I) (Cushman, 1930)
Merodon equestris	*Rhembobius abdominalis* (I) (Cushman, 1930)

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PLATES

PLATE I

FIG. 1. *Sphaerophoria cylindrica,* dorsal aspect of larva.

FIG. 2. Cross section of an aphidophagous larva (after Metcalf): a. median, b. dorsal, c. dorso-lateral, d. lateral, e. posterior ventro-lateral, and f. anterior ventro-lateral segmental spines.

FIG. 3. *Sphaerophoria cylindrica,* posterior respiratory process.

FIG. 4. *Sphaerophoria cylindrica,* posterior spiracular plates.

FIG. 5. *Sphaerophoria cylindrica,* rectal gills *in situ.*

FIG. 6. *Sphaerophoria robusta,* posterior spiracular plates.

FIG. 7. *Allograpta obliqua,* rectal gills *in situ.*

FIG. 8. *Allograpta obliqua,* posterior respiratory process.

FIG. 9. *Allograpta obliqua,* posterior spiracular plates.

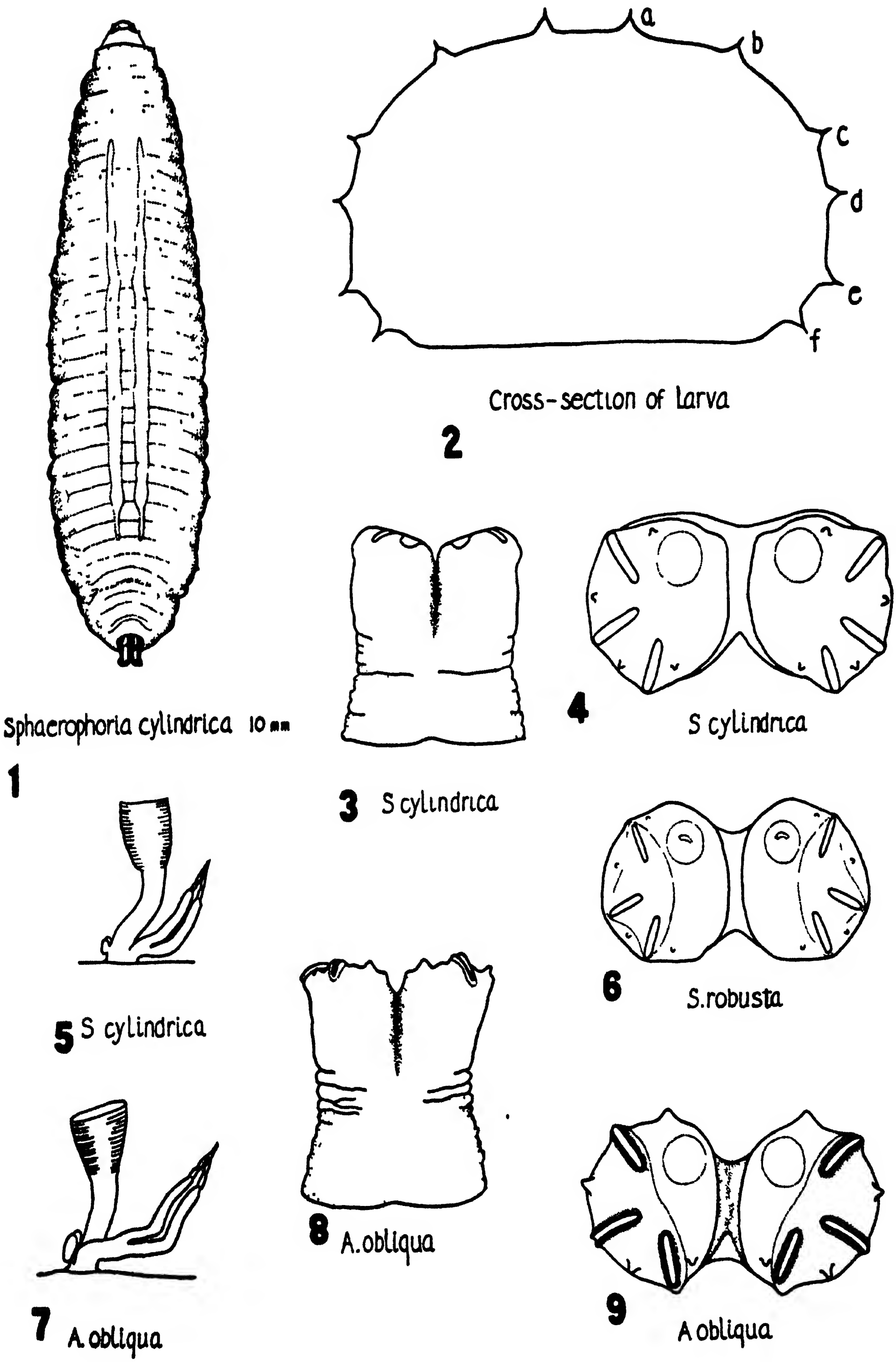

a
b
c
d
e
f
Cross-section of Larva
2
Sphaerophoria cylindrica 10 mm
1
3 S cylindrica
4 S cylindrica
5 S cylindrica
6 S.robusta
7 A.obliqua
8 A.obliqua
9 A obliqua

PLATE I

PLATE II

FIG. 10. *Mesogramma polita,* dorsal aspect of mature larva.
FIG. 11. *Mesogramma polita,* second instar larva and corn anther.
FIG. 12. *Mesogramma polita,* posterior spiracular plates.
FIG. 13. *Mesogramma polita,* puparium among florets of corn tassel.
FIG. 14. *Mesogramma marginata,* posterior spiracular plates (after Fluke).
FIG. 15. *Mesogramma marginata,* lateral aspect of puparium (after Fluke).
FIG. 16. *Mesogramma polita,* lateral aspect of puparium.
FIG. 17. *Mesogramma geminata,* posterior spiracular plates.
FIG. 18. *Mesogramma polita,* dorsal aspect of puparium.

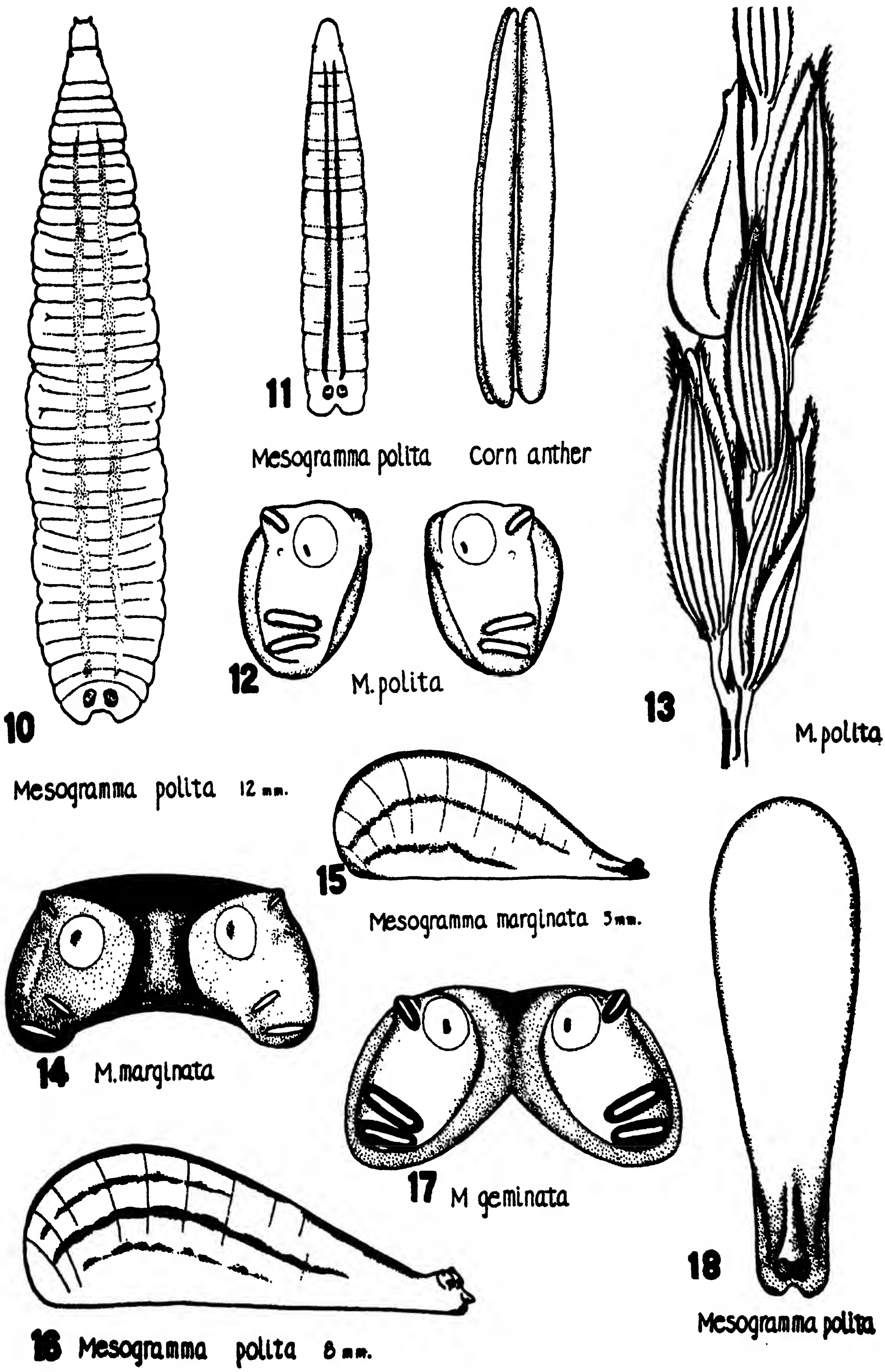

10
Mesogramma polita 12 mm.
11
Mesogramma polita
corn anther
12
M. polita
13
M. polita
14
M. marginata
15
Mesogramma marginata 5 mm.
16
Mesogramma polita 8 mm.
17
M geminata
18
Mesogramma polita

PLATE II

PLATE III

FIG. 19. *Melanostoma mellinum,* dorsal aspect of puparium and pupal respiratory horn (after Metcalf).

FIG. 20. *Platychirus perpallidus,* posterior spiracular plates (after Metcalf).

FIG. 21. *Melanostoma obscurum,* posterior spiracular plates.

FIG. 22. *Lasiophthicus pyrastri,* chitinous bars of posterior spiracle.

FIG. 23. *Eupeodes volucris,* posterior spiracular plates.

FIG. 24. *Lasiophthicus pyrastri,* posterior spiracular plates.

FIG. 25. *Eupeodes volucris,* dorsal aspect of larva.

FIG. 26. *Eupeodes volucris,* segmental spine.

FIG. 27. *Eupeodes volucris,* posterior respiratory process from above.

FIG. 28. *Lasiophthicus pyrastri,* lateral aspect of puparium.

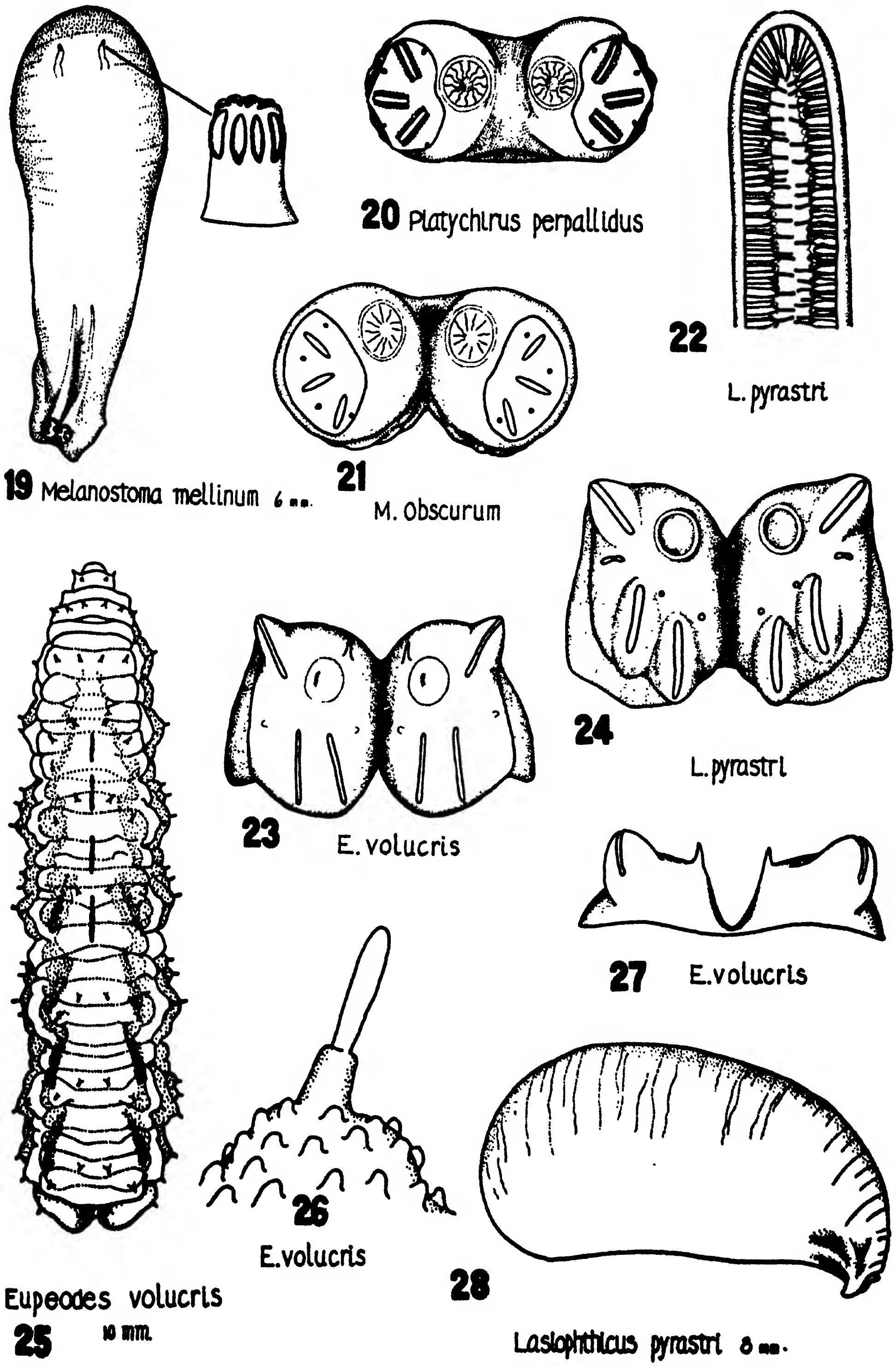

19 Melanostoma mellinum 6 mm.
20 Platychirus perpallidus
21 M. obscurum
22 L. pyrastri
23 E. volucris
24 L. pyrastri
25 Eupeodes volucris 10 mm.
26 E. volucris
27 E. volucris
28 Lasiophthicus pyrastri 8 mm.

PLATE III

PLATE IV

FIG. 29. *Syrphus rectus,* dorsal aspect of larva: d.b.v. dorsal blood vessel, d.l. dorsal line, ar. arrow, ch. chevron.
FIG. 30. *Syrphus rectus,* posterior spiracular plates.
FIG. 31. *Syrphus rectus,* posterior respiratory process from above.
FIG. 32. *Syrphus rectus,* rectal gills *in situ.*
FIG. 33. *Syrphus torvus,* posterior spiracular plates.
FIG. 34. *Syrphus rectus,* segmental spine.
FIG. 35. *Syrphus rectus,* chitinous bars of posterior spiracle.
FIG. 36. *Syrphus ribesii* var. *vittafrons,* posterior spiracular plates.
FIG. 37. *Syrphus ribesii* var. *vittafrons,* lateral aspect of puparium.
FIG. 38. *Syrphus knabi,* posterior spiracular plates.
FIG. 39. *Syrphus knabi,* posterior respiratory process from above.

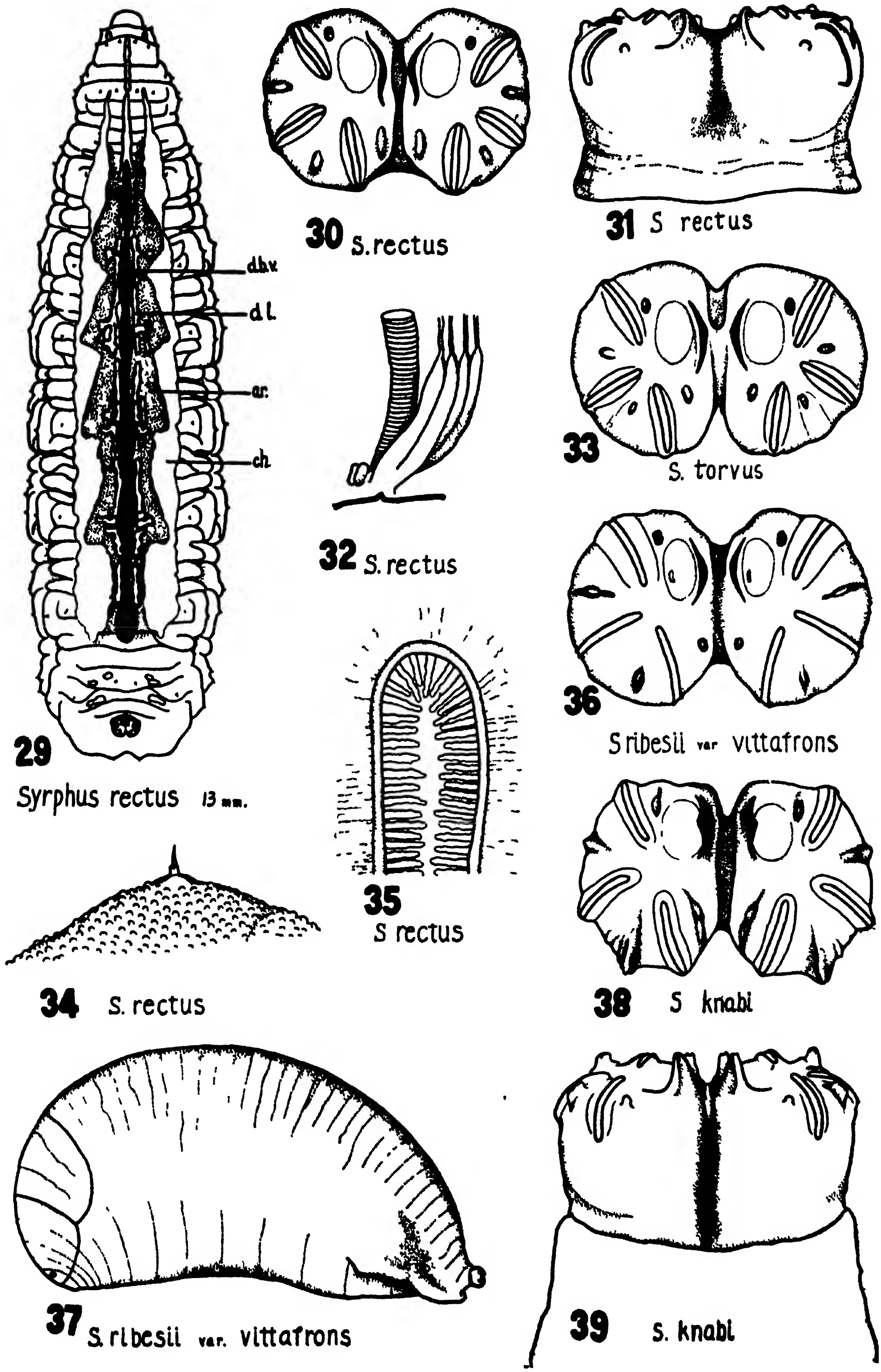

29
Syrphus rectus 13 mm.
d.b.v.
d.l.
ar.
ch.
30 S. rectus
31 S rectus
32 S. rectus
33 S. torvus
34 S. rectus
35 S rectus
36 S ribesii var vittafrons
37 S. ribesii var. vittafrons
38 S knabi
39 S. knabi

PLATE IV

PLATE V

FIG. 40. *Metasyrphus wiedemanni,* dorsal aspect of larva.

FIG. 41. *Metasyrphus wiedemanni,* seive plate of posterior spiracle.

FIG. 42. *Metasyrphus nitens* (?), posterior spiracular plates (after Metcalf).

FIG. 43. *Metasyrphus canadensis,* posterior spiracular plates.

FIG. 44. *Metasyrphus meadii,* posterior spiracular plates.

FIG. 45. *Metasyrphus wiedemanni,* posterior spiracular plates.

FIG. 46. *Metasyrphus vinelandi,* segmental spine.

FIG. 47. *Metasyrphus perplexus,* posterior spiracular plates.

FIG. 48. *Metasyrphus wiedemanni,* rectal gills extruded.

FIG. 49. *Metasyrphus vinelandi,* posterior spiracular plates.

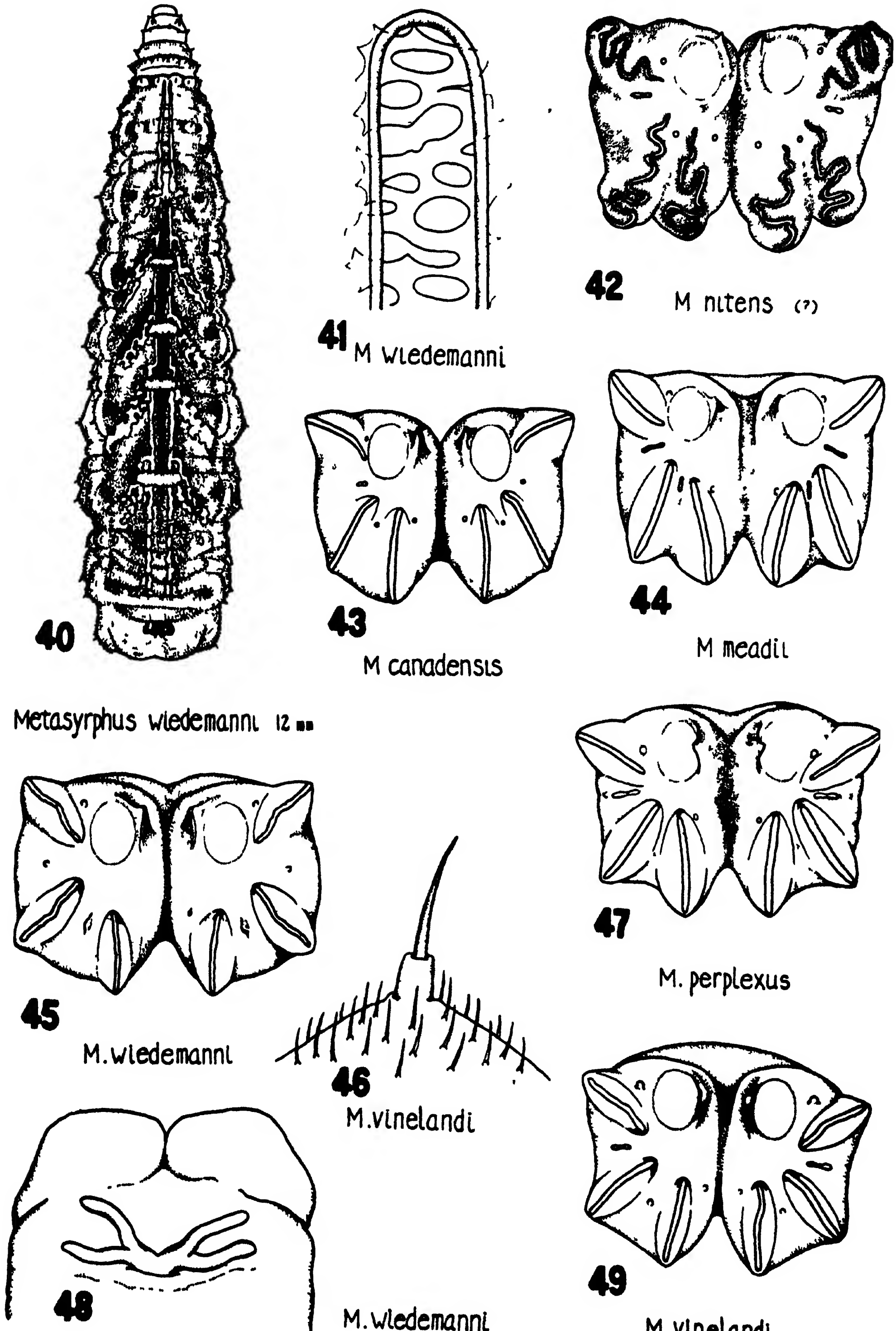

40
Metasyrphus wiedemanni 12 mm
41 M wiedemanni
42 M nitens (?)
43 M canadensis
44 M meadii
45 M.wiedemanni
46 M.vinelandi
47 M. perplexus
48 M.wiedemanni
49 M.vinelandi

PLATE V

PLATE VI

FIG. 50. *"Metasyrphus" emarginatus,* dorsal aspect of larva.
FIG. 51. *"Metasyrphus" emarginatus,* lateral aspect of puparium.
FIG. 52. *"Metasyrphus" emarginatus,* rectal gills *in situ.*
FIG. 53. *"Metasyrphus" divisus,* posterior respiratory process.
FIG. 54. *"Metasyrphus" divisus,* posterior spiracular plates.
FIG. 55. *"Metasyrphus" invigorus,* posterior spiracular plates.
FIG. 56. *"Metasyrphus" emarginatus,* segmental spine.
FIG. 57. *"Metasyrphus" emarginatus,* posterior respiratory process.
FIG. 58. *"Metasyrphus" emarginatus,* posterior spiracular plates.
FIG. 59. *"Metasyrphus" invigorus,* posterior respiratory process.

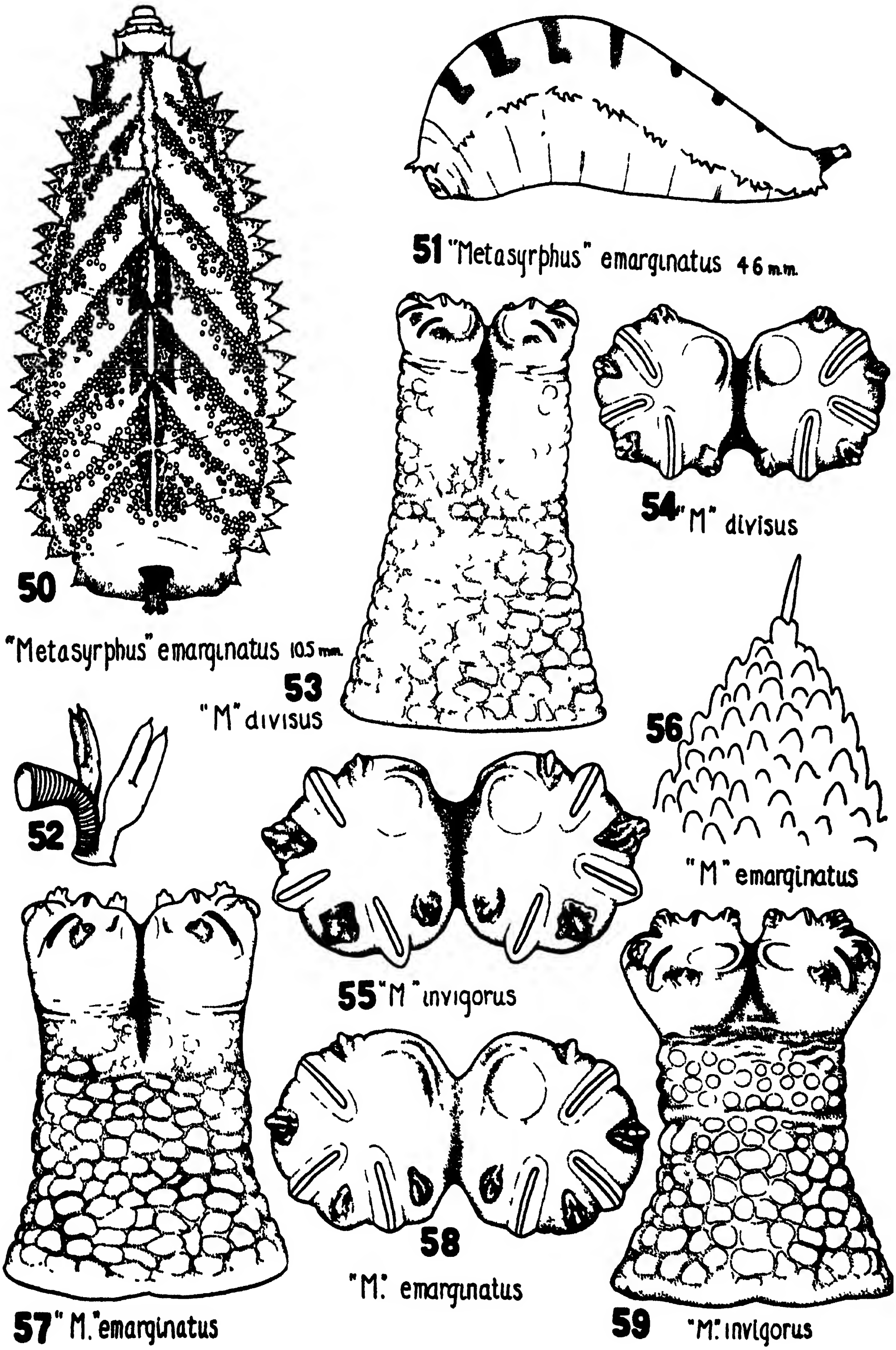
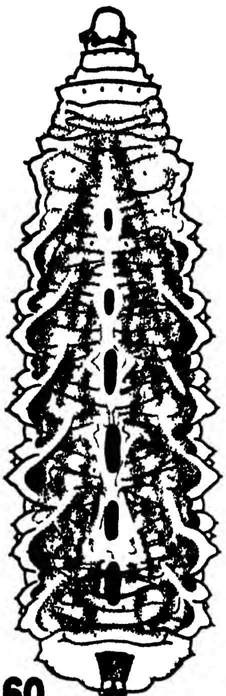

50
"Metasyrphus" emarginatus 10.5 mm.
51 "Metasyrphus" emarginatus 4.6 mm.
52
53
"M" divisus
54 "M" divisus
55 "M" invigorus
56
"M" emarginatus
57 "M." emarginatus
58
"M." emarginatus
59 "M." invigorus

PLATE VI

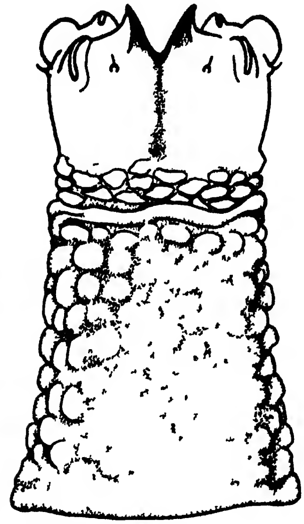
PLATE VII

FIG. 60. *Epistrophe cinctus,* dorsal aspect of larva.
FIG. 61. *Epistrophe cinctus,* posterior respiratory process.
FIG. 62. *Epistrophe triangulifer,* posterior respiratory process.
FIG. 63. *Epistrophe cinctus,* segmental spine.
FIG. 64. *Epistrophe cinctus,* posterior spiracular plates.
FIG. 65. *Epistrophe triangulifer,* posterior spiracular plates.
FIG. 66. *Epistrophe cinctus,* dorsal aspect of puparium.
FIG. 67. *Pipiza femoralis,* lateral aspect of puparium.
FIG. 68. *Epistrophe cinctus,* lateral aspect of puparium.

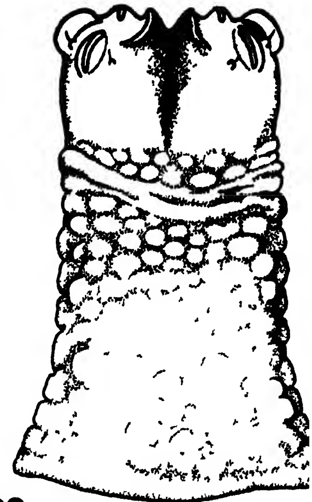


60

Epistrophe cinctus 11 mm



61 E cinctus

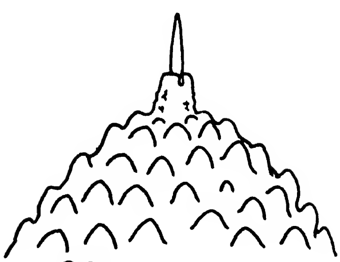


62

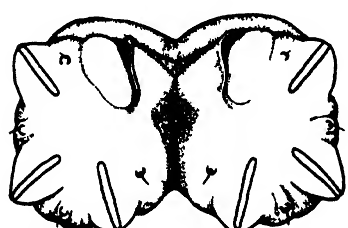
E trianguliter

64

E cinctus

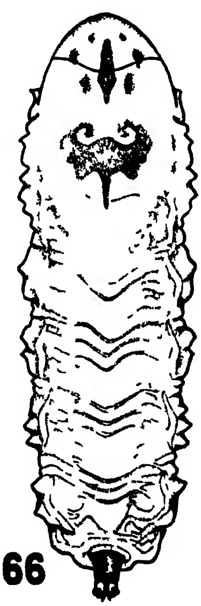


63 E. cinctus



65

E trianguliter



66

Epistrophe cinctus 8 mm

67

Pipiza femoralis 8 mm.

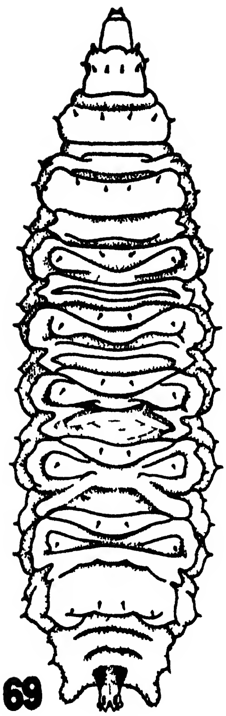
68

Epistrophe cinctus 8 mm.

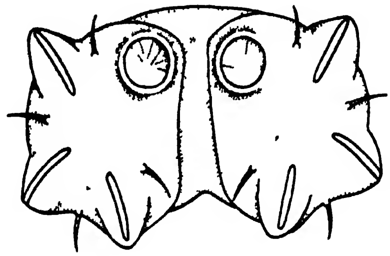
PLATE VII

PLATE VIII

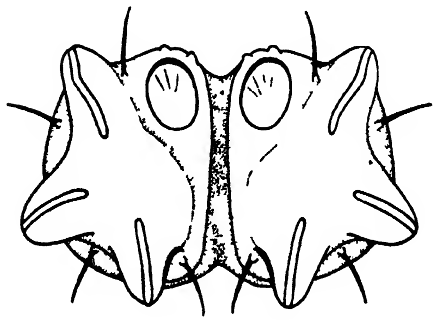
FIG. 69. *Pipiza femoralis,* dorsal aspect of larva.
FIG. 70. *Pipiza pisticoides,* posterior spiracular plates.
FIG. 71. *Pipiza femoralis,* posterior spiracular plates.
FIG. 72. *Pipiza pisticoides,* dorsal aspect of larva.
FIG. 73. *Pipiza pisticoides,* segmental spine.
FIG. 74. *Paragus bicolor,* posterior respiratory process.
FIG. 75. *Paragus tibialis,* posterior respiratory process.
FIG. 76. *Pipiza femoralis,* segmental spine.
FIG. 77. *Paragus tibialis,* lateral aspect of puparium.



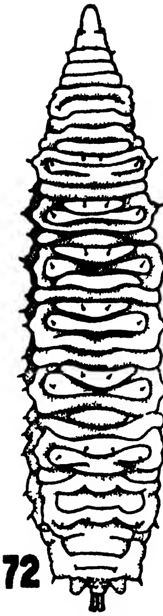
69 Pipiza femoralis 11 mm



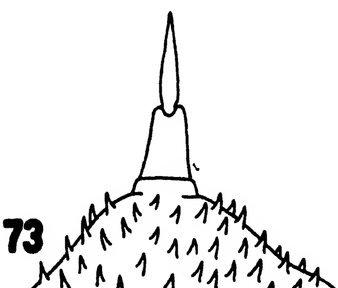
70 P pisticoides



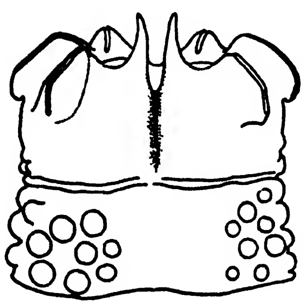
71 P femoralis



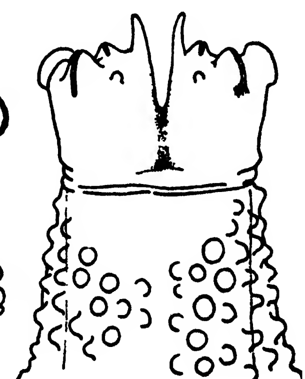
72 Pipiza pisticoides 9 mm



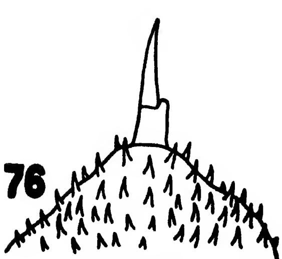
73 P. pisticoides



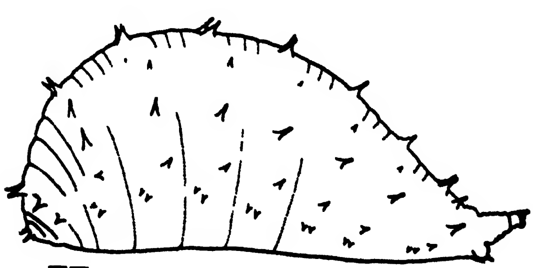
74 P. bicolor



75 P. tibialis



76 P. femoralis

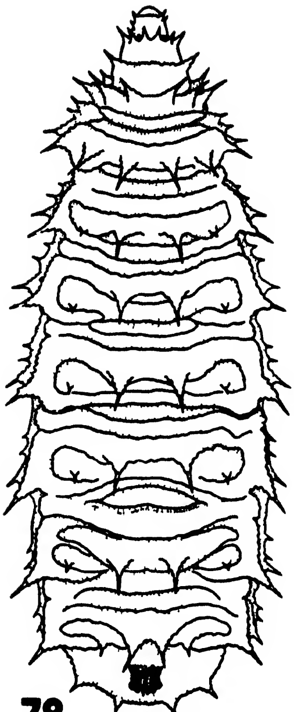


77 Paragus tibialis 2.5 mm

PLATE VIII

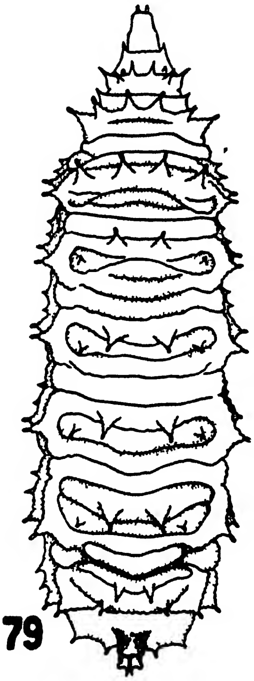
PLATE IX

FIG. 78. *Paragus bicolor,* dorsal aspect of larva.
FIG. 79. *Paragus tibialis,* dorsal aspect of larva.
FIG. 80. *Didea fasciata,* segmental spine.
FIG. 81. *Paragus bicolor,* segmental spine.
FIG. 82. *Paragus tibialis,* segmental spine.
FIG. 83. *Didea fasciata,* posterior spiracular plates.
FIG. 84. *Didea fasciata,* dorsal aspect of larva.



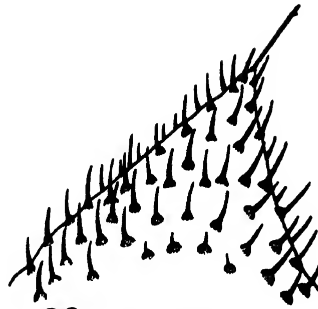
78

Paragus bicolor 7 mm

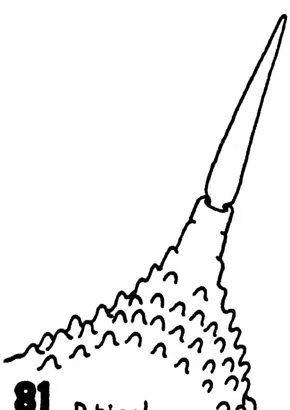


79

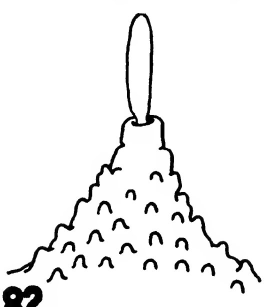
Paragus tibialis 6 mm



80 D fasciata

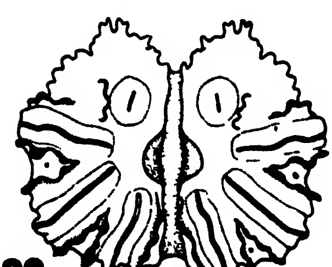


81 P bicolor



82

P tibialis



83

D. fasciata

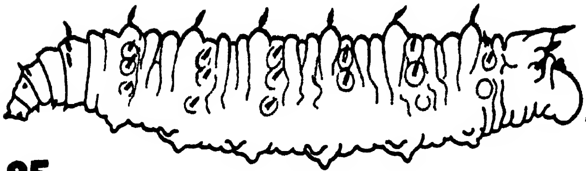
84

Didea fasciata 15 mm.

PLATE IX

PLATE X

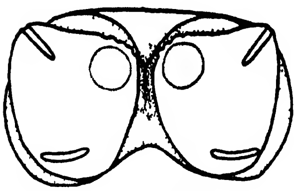
FIG. 85. *Baccha clavata,* lateral aspect of larva.
FIG. 86. *Baccha clavata,* lateral aspect of puparium.
FIG. 87. *Baccha clavata,* end view of posterior spiracular plates.
FIG. 88. *Baccha clavata,* posterior spiracular plates from below.
FIG. 89. *Baccha clavata,* segmental spine.
FIG. 90. *Baccha clavata,* posterior respiratory process from the side.
FIG. 91. *Baccha clavata,* dorsal view of puparium.
FIG. 92. *Baccha lugens,* lateral view of puparium.
FIG. 93. *Baccha lugens,* posterior spiracular plates.
FIG. 94. *Chrysotoxum pubescens,* lateral aspect of puparium (after Greene).
FIG. 95. *Chrysotoxum pubescens,* posterior spiracular plates (after Greene).



85

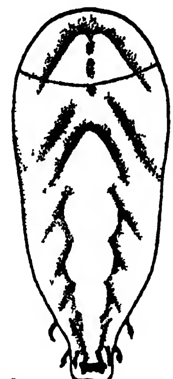
Baccha clavata 10 mm.

86 Baccha clavata 6 mm.



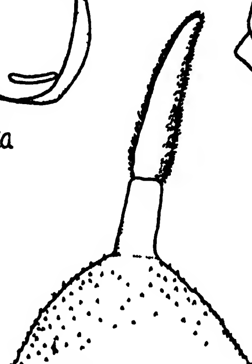
87 B clavata

88 B clavata

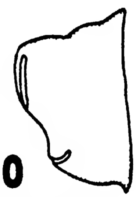


91

Baccha clavata 6 mm



89 B clavata

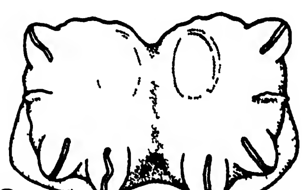


90

B clavata

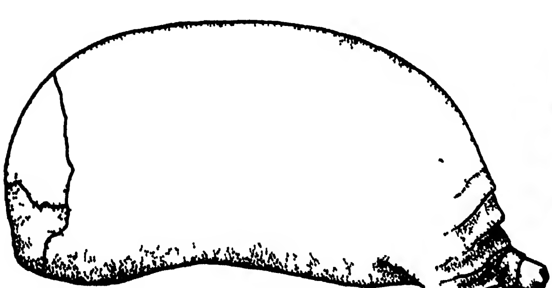
92

Baccha lugens 5 mm.

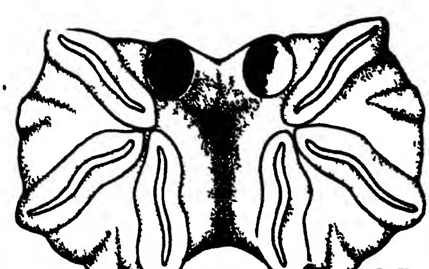


93

B lugens



94 Chrysotoxum pubescens 8mm



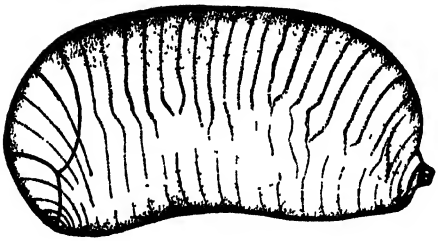
95

C pubescens

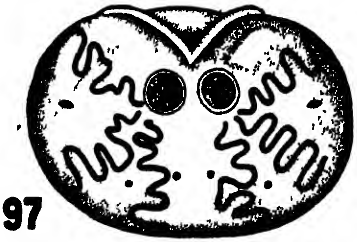
PLATE X

PLATE XI

FIG. 96. *Xanthogramma flavipes,* lateral aspect of puparium.
FIG. 97. *Xanthogramma flavipes,* posterior spiracular plates.
FIG. 98. *Xylota pigra,* lateral aspect of puparium.
FIG. 99. *Xylota fraudulosa,* lateral hooks.
FIG. 100. *Xylota nemorum,* lateral hooks.
FIG. 101. *Xylota fraudulosa,* lateral aspect of puparium.
FIG. 102. *Xylota nemorum,* dorsal aspect of puparium.
FIG. 103. *Xylota* sp., ventral aspect of larva.



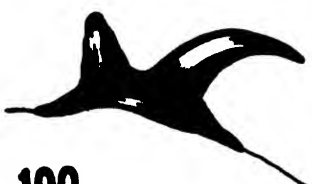
96 Xanthogramma flavipes 8 mm.



97 X. flavipes

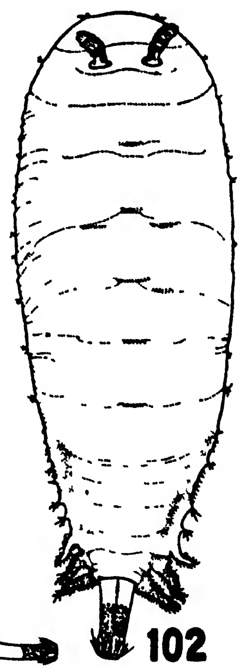
98 Xylota pigra 11 mm.

99 X. fraudulosa

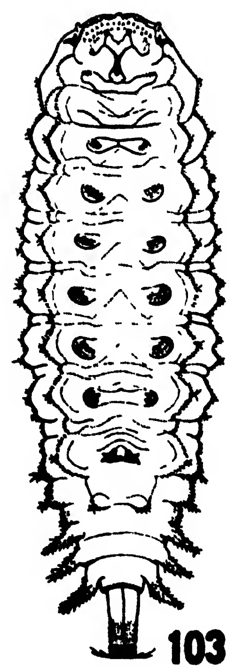


100 X. nemorum

101 Xylota fraudulosa 7 mm



102 Xylota nemorum 8 mm

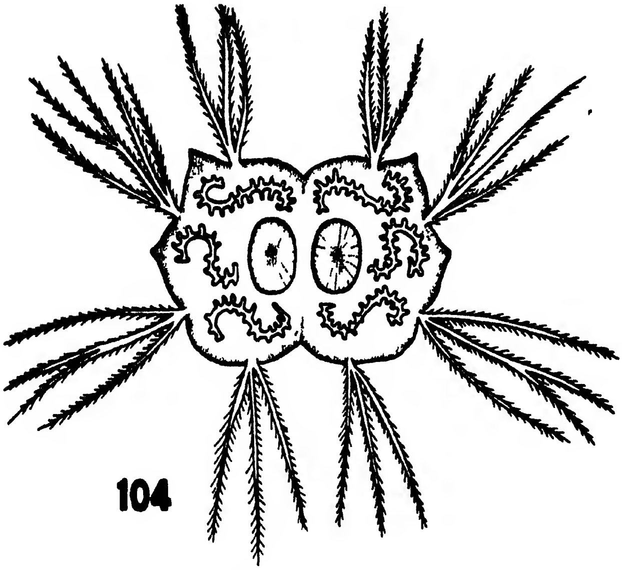


103 Xylota sp. 10 mm.

PLATE XI

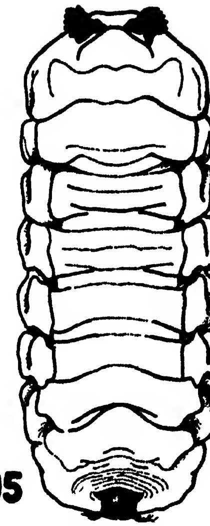
PLATE XII

FIG. 104. *Xylota nemorum,* posterior spiracular plates.
FIG. 105. *Temnostoma bombylans,* dorsal aspect of larva.
FIG. 106. *Temnostoma balyras,* posterior spiracular plates.
FIG. 107. *Temnostoma bombylans,* posterior spiracular plates.
FIG. 108. *Temnostoma bombylans,* lateral aspect of puparium.



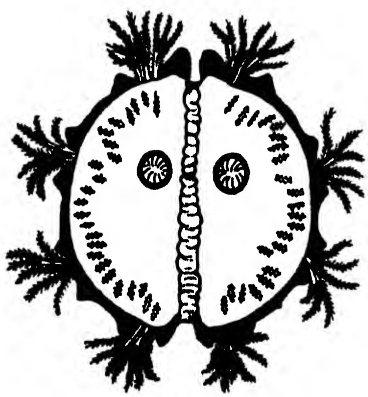
104

X. nemorum



105

Temnostoma bombylans 10 mm.

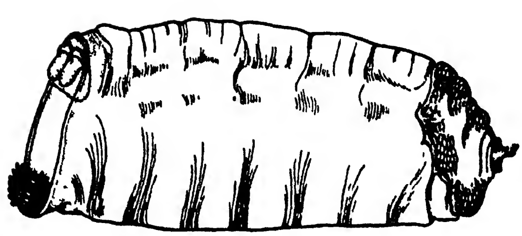


106

T. balyras

107

T. bombylans

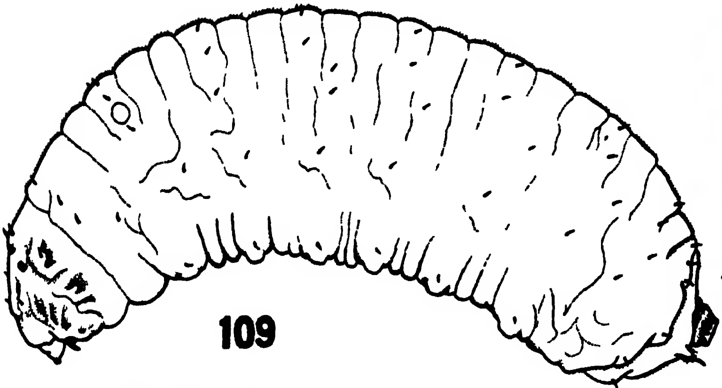


108 Temnostoma bombylans 10 mm.

PLATE XII

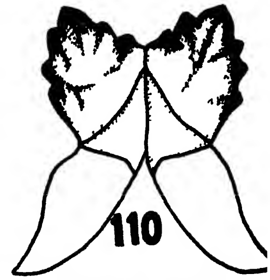
PLATE XIII

FIG. 109. *Merodon equestris,* lateral aspect of larva.
FIG. 110. *Eumerus tuberculatus,* mandibular sclerites (after Hodson).
FIG. 111. *Merodon equestris,* lateral aspect of puparium.
FIG. 112. *Merodon equestris,* posterior spiracular plate.
FIG. 113. *Eumerus strigatus,* lateral aspect of larva.
FIG. 114. *Eumerus strigatus,* mandibular sclerites (after Hodson).
FIG. 115. *Eumerus tuberculatus,* antennal papillae (after Hodson).
FIG. 116. *Eumerus strigatus,* antennal papillae (after Hodson).



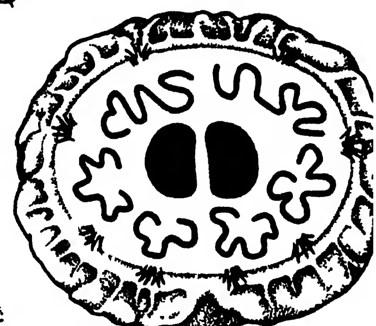
109

Merodon equestris 15 mm

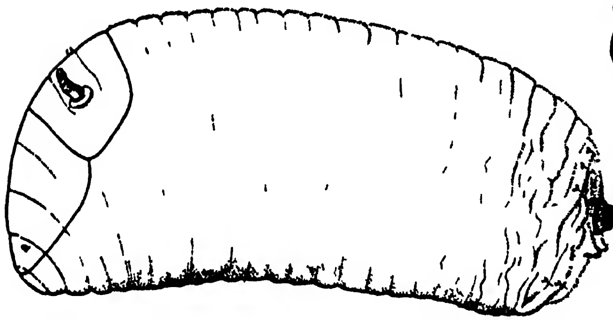


110

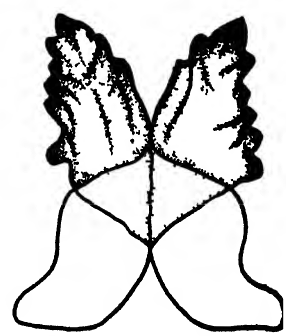
E. tuberculatus



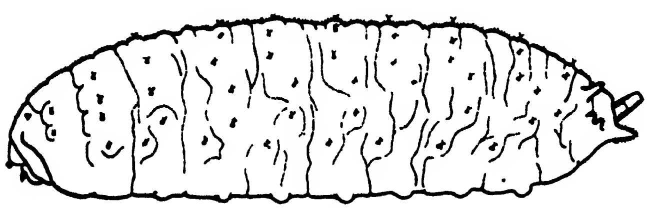
112 M. equestris



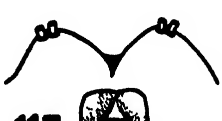
111 Merodon equestris 13 mm



114 E. strigatus

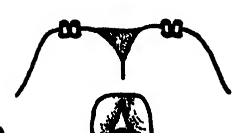


113 Eumerus strigatus 9 mm.



115

E. tuberculatus



116

E. strigatus

PLATE XIII

PLATE XIV

FIG. 117. *Syritta pipiens,* lateral aspect of larva (after Hodson).
FIG. 118. *Syritta pipiens,* posterior spiracular plates (after Metcalf).
FIG. 119. *Eumerus strigatus,* segmental spine.
FIG. 120. *Eumerus strigatus,* pupal respiratory horn.
FIG. 121. *Syritta pipiens,* pupal respiratory horn (after Metcalf).
FIG. 122. *Eumerus strigatus,* posterior spiracular plates.
FIG. 123. *Eumerus strigatus,* lateral aspect of puparium.
FIG. 124. *Syritta pipiens,* rectal gills extruded (after Krüger).
FIG. 125. *Eumerus strigatus,* rectal gills extruded and *in situ.*
FIG. 126. *Syritta pipiens,* lateral aspect of puparium (after Hodson).
FIG. 127. *Eumerus strigatus,* caudal region of larva, dorsal aspect.
FIG. 128. *Syritta pipiens,* caudal region of larva, dorsal aspect (after Metcalf).

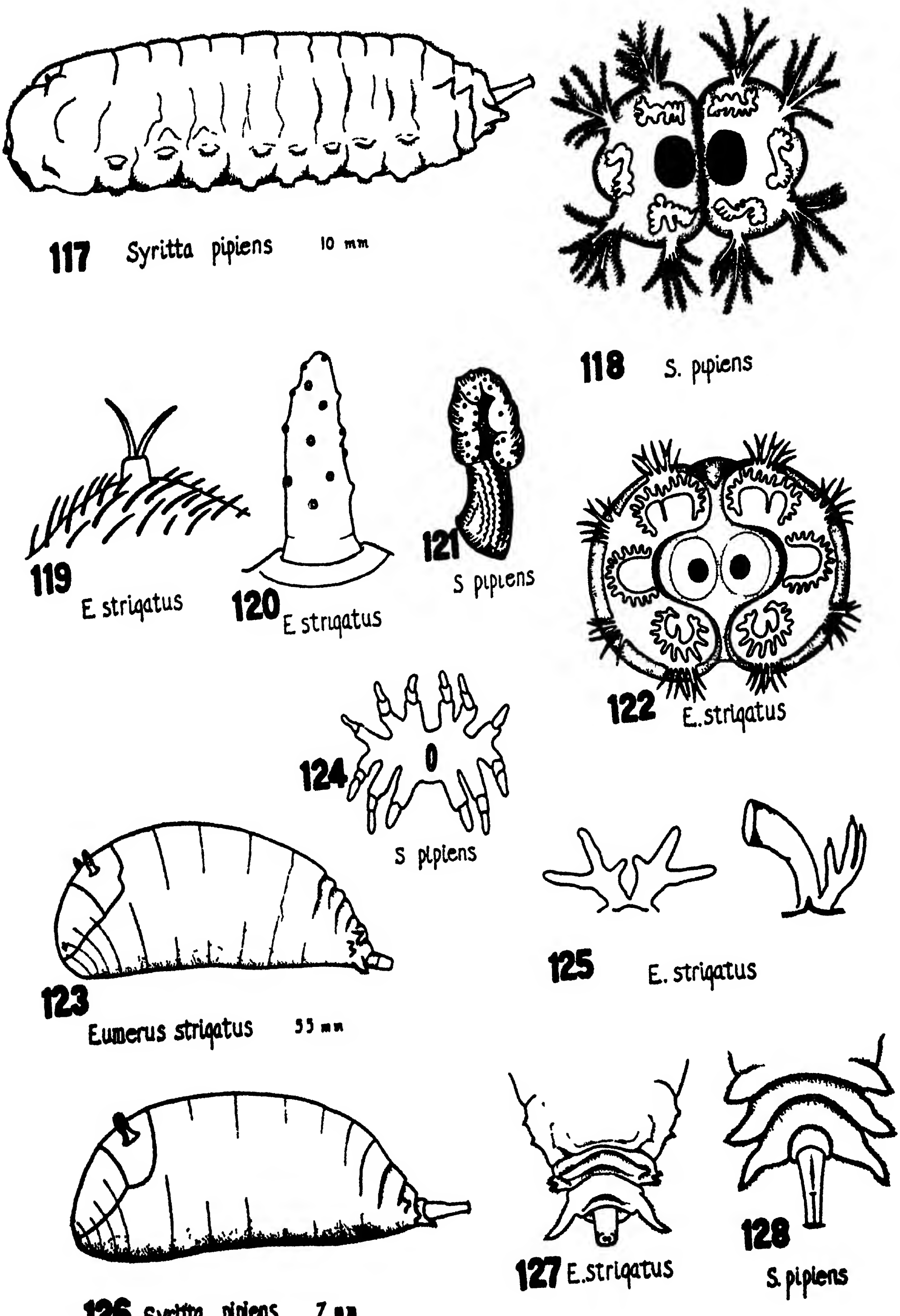
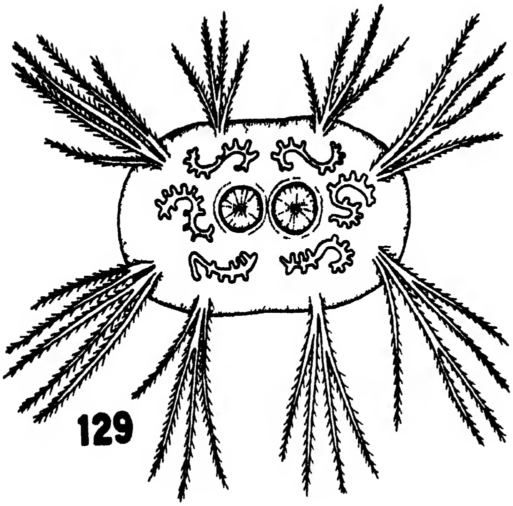

117 Syritta pipiens 10 mm
118 S. pipiens
119 E. strigatus
120 E. strigatus
121 S pipiens
122 E. strigatus
124 S pipiens
123 Eumerus strigatus
125 E. strigatus
126 Syritta pipiens 7 mm
127 E. strigatus
128 S. pipiens

PLATE XIV

PLATE XV

FIG. 129. *Brachypalpus frontosus,* posterior spiracular plate.
FIG. 130. *Brachypalpus frontosus,* lateral hook.
FIG. 131. *Brachypalpus rileyi,* lateral hooks (after Greene).
FIG. 132. *Brachypalpus frontosus,* pupal respiratory horn.
FIG. 133. *Brachypalpus rileyi,* pupal respiratory horn (after Greene).
FIG. 134. *Brachypalpus frontosus,* ventral aspect of larva.
FIG. 135. *Brachypalpus frontosus,* segmental spine.
FIG 136. *Brachypalpus frontosus,* dorsal view of anterior region.
FIG. 137. *Brachypalpus frontosus,* lateral aspect of puparium.



129

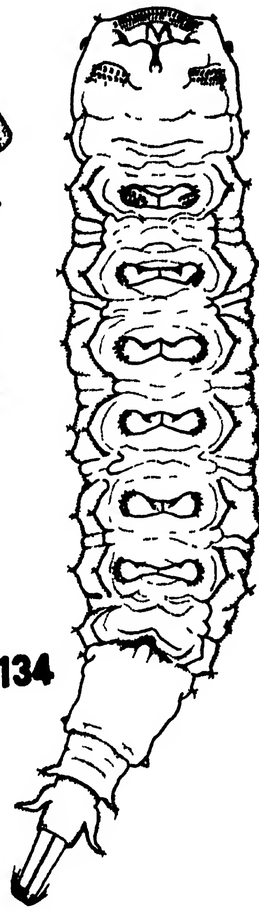
B frontosus

130

B frontosus

131

B rileyi

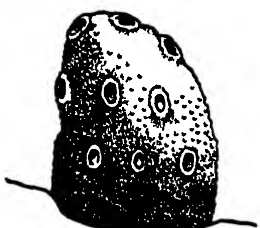


134

Brachypalpus frontosus 19 mm

132

B. frontosus



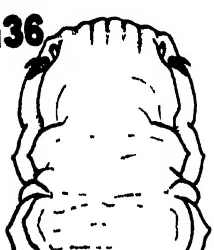
133

B rileyi

135

B frontosus

136



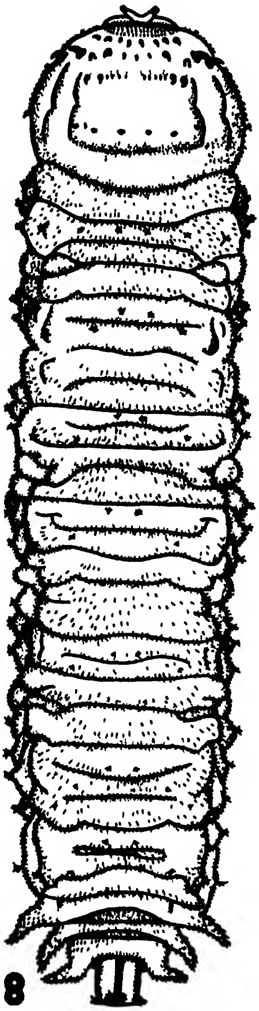
B. frontosus - dorsal view

137 Brachypalpus frontosus 14 mm.

PLATE XV

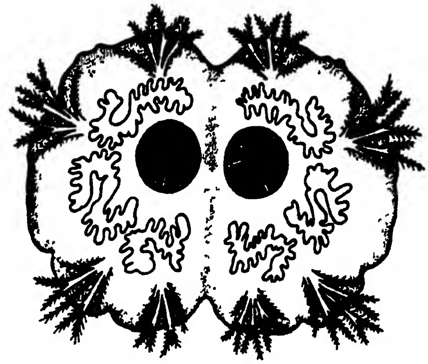
PLATE XVI

FIG. 138. *Tropidia quadrata,* dorsal aspect of larva (after Metcalf).
FIG. 139. *Tropidia quadrata,* posterior spiracular plates (after Metcalf).
FIG. 140. *Brachopa vacua,* dorsal aspect of puparium (after Greene).
FIG. 141. *Tropidia quadrata,* lateral aspect of puparium (after Metcalf).
FIG. 142. *Volucella* sp., dorsal aspect of larva.

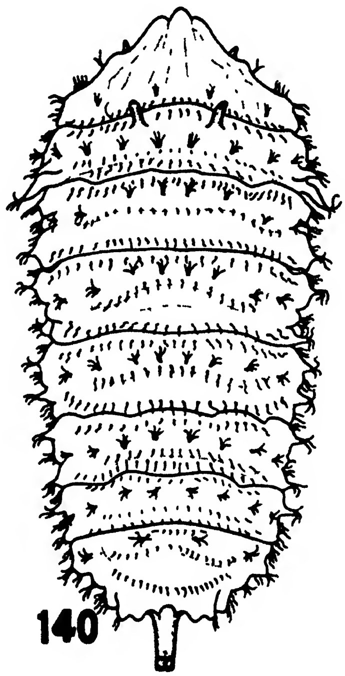


138

Tropidia quadrata 16 mm

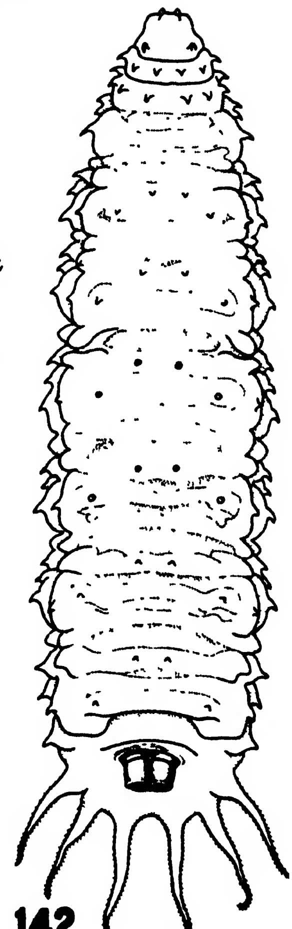


139 T. quadrata



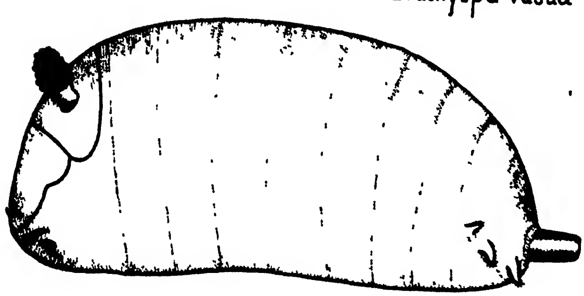
140

Brachyopa vacua 8 mm



142

Volucella sp. 19 mm

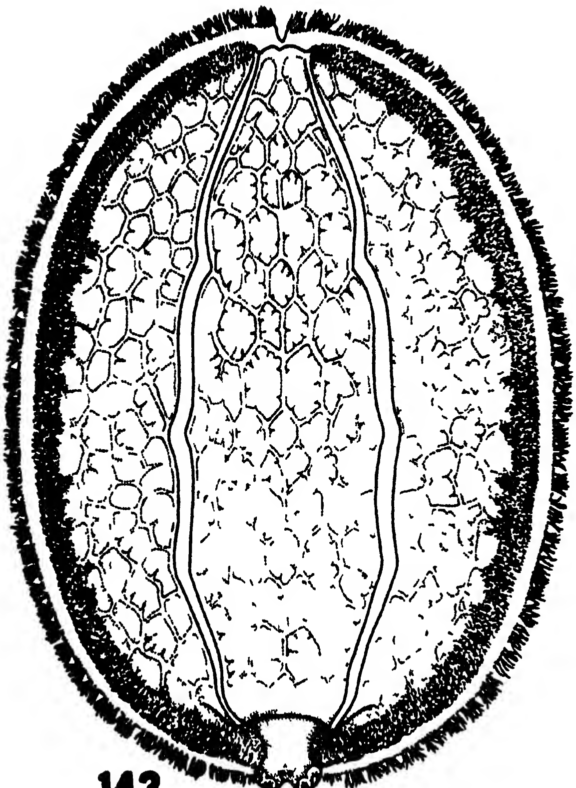


141 Tropidia quadrata 9 mm.

PLATE XVI

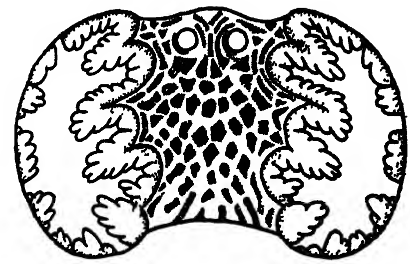
PLATE XVII

FIG. 143. *Microdon* sp., dorsal aspect of larva.
FIG. 144. *Microdon* sp., posterior spiracular plates.
FIG. 145. *Volucella* sp., posterior spiracular plates.
FIG. 146. *Cerioides signifera*, lateral aspect of puparium.

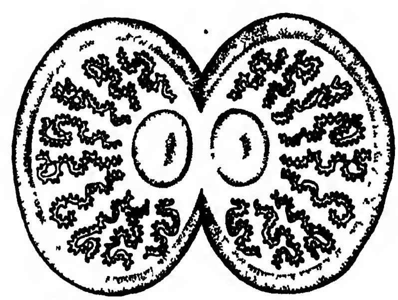


143

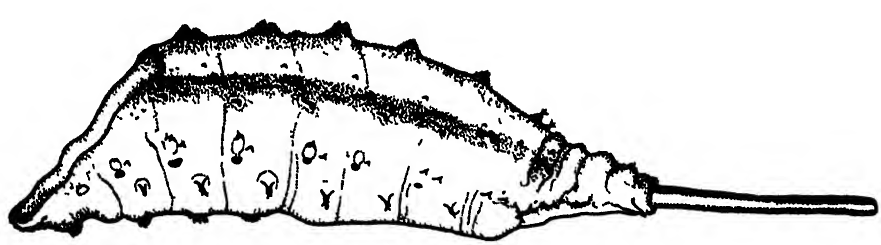
Microdon sp. 10 mm



144 Microdon sp.



145 Volucella sp.



146 Cerioides signifera 14mm.

PLATE XVII

INDEX

Agromyzidae, 20
Allograpta Osten Sacken, 17, 22, 25, 27
  obliqua Say, 27
Aphidoletes meridionalis Felt, 20
arrow, 43

Baccha Fabricius, 22, 23, 25, 73
  clavata Fabricius, 73
  lugens Loew, 74
balyras (Walker), *Temnostoma,* 81, 83
bicolor Fabricius, *Paragus,* 70
bicolor Loew, *Xylota,* 78, 80
bombylans Fabricius, *Temnostoma,* 81
Brachyopa Meigen, 23, 26, 95
  vacua Osten Sacken, 95
Brachypalpus Macquart, 91
  frontosus Loew, 23, 26, 91, 92
  rileyi Williston, 24, 26, 91, 93

canadensis (Curran), *Metasyrphus,* 50, 55
carina, 20
Cecidomyiidae, 20
Ceria signifera Loew, 98
Ceria willistoni Kahl, 98
Cerioides Rondani, 98
  signifera (Loew), 23, 26, 98
Chalcidae, 18, 99
chevrons, 43
chitinous bars, 39, 42, 49
Chrysotoxum Meigen, 75
  pubescens Loew, 24, 26, 75
cinctus (Fallén), *Epistrophe,* 63
circular plate, 12, 14, 20
clavata Fabricius, *Baccha,* 73
coarctatus Loew, *Microdon,* 97
Cyaniris ladon Cramer, 20
cylindrica Say, *Sphaerophoria,* 28, 29
Cynipidae, 18, 99

Didea Macquart, 22, 25, 72
  fasciata fuscipes Loew, 72
divisa (Williston), *"Metasyrphus,"* 59
divisus (Williston), *"Metasyrphus,"* 60
dorsal line, 43
dorsal spur, 12, 21

eggs of Syrphidae, 10
emarginatus group, 17, 18, 22, 25, 57
emarginatus (Say), *"Metasyrphus,"* 59
Epistrophe Walker, 17, 18, 22, 24, 63
  cinctus (Fallén), 63
  triangulifer Zetterstedt, 63, 65
equestris Fabricius, *Merodon,* 84
erraticus Curran, Platychirus, 37
Eumerus Meigen, 23, 27, 85
  narcissi Smith, 86
  strigatus Fallén, 87
  tuberculatus Rondani, 87, 88
Eupeodes Osten Sacken, 22, 25, 26, 40
  volucris Osten Sacken, 41

false head, 13, 21
fasciata fuscipes Loew, *Didea,* 72
felix (Fluke), *"Metasyrphus,"* 62
femoralis Loew, *Pipiza,* 66, 67
flavipes Loew, *Xanthogramma,* 24, 76
food habits, 15
fraudulosa Loew, *Xylota,* 78
frontosus Loew, *Brachypalpus,* 23, 26, 91, 92

geminata Say, *Mesogramma,* 31, 34
generic relationships, 17
globosus Fabricius, *Microdon,* 97
glossary, 20

hyperboreus Staeger, *Platychirus,* 37

Ichneumonidae, 18, 99
interspiracular nodules, setae, lamellae, 12, 21
invigorus (Curran), *"Metasyrphus,"* 62

keys, 21, 28, 31, 43, 49, 63, 66, 70, 78, 81, 87, 91
  to genera, larvae, 21
  to genera, puparia, 24
knabi Shannon, *Syrphus,* 43, 47

larva, 11
  aphidophagous type, 11
  saprophytic type, 13
  Microdon type, 14
larvae resembling Syrphidae, 19
Lasiophthicus Rondani, 22, 25, 38
  pyrastri Linnaeus, 39
lateral thorns, 21
Leucopis americana Malloch, 20

lugens Loew, *Baccha,* 74
Lycaenidae, 20

marginata Say, *Mesogramma,* 31, 33
meadii (Jones), *Metasyrphus,* 50, 54
megalogaster Snow, *Microdon,* 97
Melanostoma Schiner, 17, 18, 22, 24, 26, 34
  mellinum Linnaeus, 35
  obscurum Say, 36
mellinum Linnaeus, *Melanostoma,* 35
menthrastri Linnaeus, *Sphaerophoria,* 30
Merodon Meigen, 23, 27, 83
  equestris Fabricius, 84
Mesogramma Loew, 17, 22, 25, 30
  geminata Say, 31, 34
  marginata Say, 31, 33
  polita Say, 31
  "Metasyrphus" emarginatus group, 17, 18, 22, 25, 57
  divisa (Williston), 59
  divisus (Williston), 60
  emarginatus (Say), 59
  felix (Fluke), 62
  invigorus (Curran), 62
  weborgi (Fluke), 59
Metasyrphus Matsumura and Adachi, 17, 18, 22, 26, 49
  canadensis (Curran), 50, 55
  meadii (Jones), 50, 54
  nitens ? (Zetterstedt), 24, 49, 55
  perplexus (Osburn), 50, 53
  vinelandi (Curran), 50, 52
  wiedemanni (Johnson), 50
Microdon Meigen, 24, 26, 96
  coarctatus Loew, 97
  globosus Fabricius, 97
  megalogaster Snow, 97
  piperi Knab, 97
  tristis Loew, 97
mouth-hood, 13

narcissi Smith, *Eumerus,* 86
nemorum Fabricius, *Xylota,* 78, 79
nigra Greene, *Volucella,* 26, 96
nitens ? (Zetterstedt), *Metasyrphus,* 24, 49, 55

obliqua Say, *Allograpta,* 27
obscurum Say, *Melanostoma,* 36
operculum, 15, 21

Paragus Latreille, 23, 25, 70
  bicolor Fabricius, 70
  tibialis Fallén, 71
parasites, 18, 99
perpallidus Verrall, *Platychirus,* 38
perplexus (Osburn), *Metasyrphus,* 50, 53
pigra Fabricius, *Xylota,* 78, 79
piperi Knab, *Microdon,* 97
pipiens Linnaeus, *Syritta,* 90
Pipiza Fallén, 23, 25, 65
  femoralis Loew, 66, 67
  pistacoides Williston, 66, 67
  radicum Walsh and Riley, 66, 69
pistacoides Williston, *Pipiza,* 66, 67
Platychirus St. Fargeau and Serville, 17, 18, 22, 25, 34, 36
  hyperboreus Staeger, 37
  perpallidus Verrall, 38
  quadratus Say, 36
polita Say, *Mesogramma,* 31
posterior respiratory process, 21
posterior spiracles, 12, 13, 21
posterior spiracular plate, 12, 14, 21
pubescens Loew, *Chrysotoxum,* 24, 26, 75
pupal respiratory horns, 15, 21
pupariation, 15
puparium, 14
  aphidophagous type, 14
  saprophytic type, 15
  Microdon type, 15
pyrastri Linnaeus, *Lasiophthicus,* 39

quadrata Say, *Tropidia,* 94
quadratus (Say), *Platychirus,* 36

radicum Walsh and Riley, *Pipiza,* 66, 69
rectal gills, 11, 12, 14, 21, 27, 32, 43, 49, 59, 68, 71, 73, 74, 88, 91
rectus Osten Sacken, *Syrphus,* 43, 44
ribesii Linnaeus, *Syrphus,* 45
ribesii vittafrons Shannon, *Syrphus,* 43, 45
rileyi Williston, *Brachypalpus,* 24, 26, [illegible], 92
robusta Curran, *Sphaerophoria,* 28, 29

scripta Fluke, *Sphaerophoria,* 29
segmental spines, 12, 21
signifera (Loew), *Cerioides,* 23, 26, 98

Sphaerophoria St. Fargeau and Serville, 17, 22, 25, 28
cylindrica Say, 28, 29
menthrastri Linnaeus, 30
robusta Curran, 28, 29
scripta Fluke, 29
spiracles, 21
strigatus Fallén, *Eumerus,* 87
Syritta St. Fargeau and Serville, 23, 27, 89
pipiens Linnaeus, 90
Syrphus Fabricius, 17, 18, 22, 26, 42
knabi Shannon, 43, 47
rectus Osten Sacken, 43, 44
ribesii Linnaeus, 45
ribesii vittafrons Shannon, 43, 45
torvus Osten Sacken, 43, 46

Temnostoma St. Fargeau and Serville, 24, 26, 81
balyras (Walker), 81, 83
bombylans Fabricius, 81
tibialis Fallén, *Paragus,* 71
torvus Osten Sacken, *Syrphus,* 43, 46
triangulifer Zetterstedt, *Epistrophe,* 63, 65
tristis Loew, *Microdon,* 97
Tropidia Meigen, 24, 26, 94
quadrata Say, 94
tuberculatus Rondani, *Eumerus,* 88

vacua Osten Sacken, *Brachyopa,* 95
vinelandi (Curran), *Metasyrphus,* 50, 52
Volucella Geoffrey, 23, 27, 96
nigra Greene, 26, 96
volucris Osten Sacken, *Eupeodes,* 41

weborgi (Fluke), *"Metasyrphus,"* 59
wiedemanni (Johnson), *Metasyrphus,* 50

Xanthogramma Schiner, 18, 57, 76
flavipes Loew, 24, 76
Xylota Meigen, 23, 26, 77
bicolor Loew, 78, 80
fraudulosa Loew, 78
nemorum Fabricius, 78, 79
pigra Fabricius, 78, 79